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TRANSYLVANIA AND ITS RELATIONS TO ANCIENT DACIA AND MODERN RUMANIA

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IN the last three and twenty years I have had the good fortune on several occasions to visit various parts both of Transylvania and of the countries which immediately surround it. Although my visits have been mainly connected with matters of archæological or historical interest rather than with pure geography, I have ventured to accept the kind invitation of your Council to address you to-night, hoping that what I shall say may be deemed to come within the limits of geographical science. The photographs with which this lecture is illustrated have nearly all been taken by my wife, Mrs. Dickinson Berry, M.D., who has accompanied me on all my journeys in Transylvania and Rumania. The maps with few exceptions have been drawn and coloured for me by my friend Lieutenant Count di Borelli, of the Serbian Army. I am indebted also to the officials of the Society for much kind help.

Physical Features of Transylvania and the Surrounding Country.

The district with which I have to deal is that comprised within the rivers Theiss, Dniester and Danube. This area forms roughly a spherical triangle. In the centre of this is another much smaller spherical triangle of mountains, forming the most easterly portion of the Carpathians. This smaller triangle is Transylvania. The area between the two triangles of rivers and mountains respectively forms a zone of relatively low-lying country, nearly flat, or with a gentle slope outwards towards the rivers. This outer zone of lower elevation is broken, however, in two places. The principal interruption is on the north where the main range of the Carpathians is prolonged from the Transylvanian Mountains in a north-westerly direction, at first dipping gradually downwards, and then rising again somewhat rapidly to join the highest peaks of the Carpathians (the Tatra Mountains), in the north of Hungary. Also, from the south-west corner of Transylvania, a short and much broken range of hills extends in a southerly direction to join the mountains of North-East Serbia. It is here that the Danube, for a distance of some 80 miles, between Bazias and

the Iron Gate below Orsova, has cut a magnificent gorge through the mountains on its way from the plains of Hungary to those of Rumania and Bulgaria.*

A journey by steamer through this gorge, or better still by the excellent Szechenyi road (Fig. 8) which skirts the north bank as far as Orsova, affords a good opportunity of observing the complicated folded structure of the Carpathians (Fig. 3). From Orsova the traveller who is interested in ancient trade routes will do well to follow the road which leads thence northwards in the Banat of Temesvar by the old Roman town of Mehadia to Karansebes, crossing the low pass of the Porta Orientalis, the gateway to the East. After the destruction of Trajan's second-century road along the southern (or Serbian) shore of the Danubian gorge, the latter became impassable for traffic either by land or water until, in the nineteenth century, navigation became possible by the blowing up of the obstructing rocks of the channel, and land traffic was restored by the construction of the Szechenyi road. During the whole of the intervening period, the route by the Porta Orientalis was the main avenue of communication between the plains of Hungary and those of Rumania and Northern Bulgaria. This route, now fallen into comparative disuse, led up the Temes valley to the pass and then descended to the Danube at Orsova and so into Rumania. From Karansebes the student of history who desires to follow in the footsteps of Trajan will do well to ascend the pretty valley of the Bistritza by a tolerable road to the so-called Iron Gate at its head (not to be confused with the Iron Gate of the Danube). Here the emperor in his first Dacian war received a check at the hands of the barbarians, and after the storming of the pass he advanced to the capture of the Dacian capital Sarmizegethusa, the modern village of Varhély (Rumanian Gradistea), on the Transylvanian side of the boundary between this country and the Banat of Temesvar. This route by way of the Danube gorge, the Porta Orientalis, and the valley of the Bistritza affords one of the most picturesque and interesting approaches to Transylvania, and, from personal knowledge we can strongly recommend it to the bicyclist or pedestrian. A slight *détour* of a few miles from Orsova will take him to the delightful health resort of Herculesbad, in the romantic valley of the Cserna. Here he may bathe in the hot water which attracted the Romans in olden times, and will see in one of the public baths a statuette of Hercules carved in the living rock by these ancient inhabitants of the place. Or he may wander up the pretty valley to the boundary of Rumania marked by a line of cairns. A stiff climb through the woods will take him to the summit of Domogled, at an altitude of 3000 feet, whence a glorious view extends over a large part of Little Wallachia.

The general configuration of Transylvania may be compared to that of

* An excellent geological map of this gorge on a scale of 1 : 115,000 has been published by Dr. Franz Schafarzik in *Földtani Közlöny*, vol. 33 (Budapest, 1903), with descriptive paper (in German).

a shallow and somewhat triangular basin, raised on a low pedestal and slightly tilted up on the eastern side. In the north-west a gap in the rim of the basin gives exit to the Szamos River, while at the south-west corner a similar gap allows the passage of the Maros. A deep crack in the middle of the southern lip of our basin gives exit to the River Olt, through the Red Tower pass. These three rivers and their tributaries are responsible for the drainage of almost the whole of Transylvania.

On the extreme north, the boundary of Transylvania follows accurately the watershed between the headwaters of the Szamos and of the Theiss (in the Hungarian county of Maramaros). On the east, owing to the fact that the boundary does not follow the watershed of the main Carpathian range, but lies in most places considerably to the east of it, numerous streams, rising in Transylvania, pass in a general south-easterly direction to the Rumanian river Sereth. On the west, in a similar manner, the Transylvanian boundary cuts off in two places some of the headwaters of the Körös, a direct tributary of the Theiss. On the south the boundary follows almost exactly the watershed of the South Carpathians or Transylvanian Alps, but is cut across, as already mentioned, near its centre by the great river Olt. In the extreme south-west corner the boundary again leaves the main watershed and passes to the south, so as to include the upper part of the otherwise Rumanian river Jiul. Further south-west the boundary between Rumania and the Banat is still more irregular, following no natural physical line. The boundary, here marked by a line of cairns, as already mentioned, descends obliquely from the Domogled Mountain in Rumania, crosses the Cserna River and then ascends obliquely on the opposite side of the valley.

The central portion of Transylvania forms thus an elevated tableland, or rather a shallow elevated basin, surrounded on all sides by mountains rising to heights of from 2000 to over 8000 feet.* The slopes of the mountains are for the most part clothed with forests, in which oak, elm, beech and ash, and, higher up, coniferous trees predominate. It is from

* The heights (in metres) of the various mountains forming the ring round Transylvania are as follows: Starting in the north-west at the Szamos River—North: Lapos Mountains, Czibles 1842; Rodna Mountains, Kuhhorn 2263. East: Györgyö Mountains, Kelemenhavas 2013, Pietrosz 2083; Csik Mountains, Nagy Hagymas 1794, Tarhavas 1662; Hargitta Mountains, 1798; Barotta Mountains, Kükükhegy 1560; Haromszeker Mountains, Büdös 1110; Bereczker Mountains, Nagy Sandor 1640, Lakocz 1778, Csiljanos 1605. South: Bodza Mountains, Csukas 1958; Burzenland Mountains, Bucsecs 2508, Königstein (Kiralyho) 2241; Fogaras Mountains, Negoi 2544 (and neighbouring peaks Vunetara alui Butjan 2510, Vistamare 2520, Verfu Urli 2479, Szuru 2288; Sibin Mountains, Frumoasze (Csindrel) 2248; Sebesell Mountains, Surian 2061, Verfului Petru 2133; Paring Mountains, Verfu Mundri 2520, Karsia 2047, Paring (peak) 2075; Vulcan Mountains, Strazsa 1870; Hatszeg Mountains, Retjezat 2477, Verfu Pelaga 2506. West: Cserna Mountains, Ruszka 1500; Verfu Petri 2180, Transylvanian Erzgebirge, Detunata 1114; Bihar Mountains, Bihar 1842, Vlegyasza 1844; Krasna or Meszes Mountains, Ejszakhegy 712 metres (from Bielz-Sigerus, 'Siebenbürgen:' Hermannstadt, 1903).

these dense forests that the country derives its name of Transylvania ("beyond the woods"). The Hungarian and Rumanian names Erdély and Ardealu also both mean wooded country. The German name Siebenbürgen, on the other hand, has nothing to do with wood (nor with seven towns), but is perhaps connected with the ancient Wallach name of town and river Sibin (Hungarian Nagy Szeben). The Maros River and its tributaries show a general tendency to run in a south-westerly direction, converging towards the south-western corner of the country, where the land sinks as low as 600 feet. The average elevation of the rest of the central plateau is from 1000 to 1600 feet, contrasting markedly with the lowlands of Central Hungary and of Wallachia, Moldavia and Bessarabia.

Geological Features.

The scenery of a country is so intimately connected with its geology that it will help us to understand the present physical configuration and structure of Transylvania if we glance for a moment at the geological history of the land. In early Tertiary (Eocene) times most of our area lay beneath the waters of the great sea which at that time covered south-eastern Europe. Parts of the Carpathians and other lands, including much of the mountainous ring that now surrounds Transylvania, stood up as islands in that sea. The great but slow upheaval of mid-Tertiary times which was chiefly responsible for the raising of the Alps, contributed also to the further elevation of the Carpathians, as a great folded chain of mountains. The gradual uprise of the sea-floor during later Tertiary times and the isolation of detached areas of sea "caused the south-east of Europe to present some resemblance to the great Aralo-Caspian depression of the present time" (A. Geikie, 'Textbook of Geology,' 2nd edit., p. 882). In Pliocene times we have in the Vienna basin the features of "an isolated gulf gradually freshening like the modern Caspian, by the inpouring of rivers; but on both sides of the Carpathian range there were bays nearly cut off from the main body of water exposed to so copious an evaporation without counterbalancing inflow that this salt was deposited over the bottom." The depression of Central Transylvania was one of these bays. These great deposits of salt, of which Bielz mentions no less than thirty-seven in Transylvania alone, constitute one of the principal sources of mineral wealth in the country* (Bielz-Sigerus, 'Siebenbürgen,' 3rd edit., p. 102: Hermannstadt, 1903). As the land continued to rise, the great Transylvanian bay became a dry land basin, the last remnant of Tertiary sea in this region being at the lowest or south-west corner of the area

* Geikie describes the remarkable deposit at Parajd, in the valley of the little Kokel River, east of Maros Vasarhely, "where a mass of rock salt has been accumulated having a maximum of 7550 feet in length, 5570 feet in breadth and 590 feet in depth, and estimated to contain upwards of 10,595 millions of cubic feet of rock salt" (*op. cit.*, p. 882).

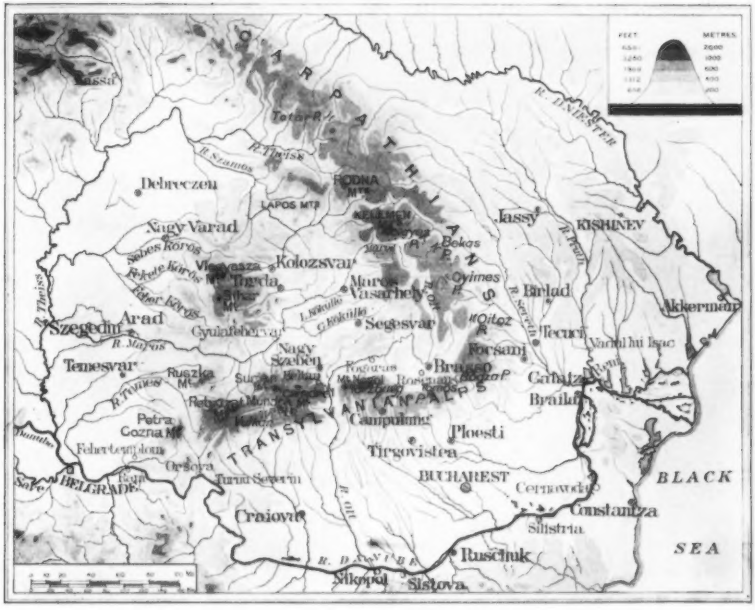


Fig. 1.—Orographical Sketch-map of Transylvania

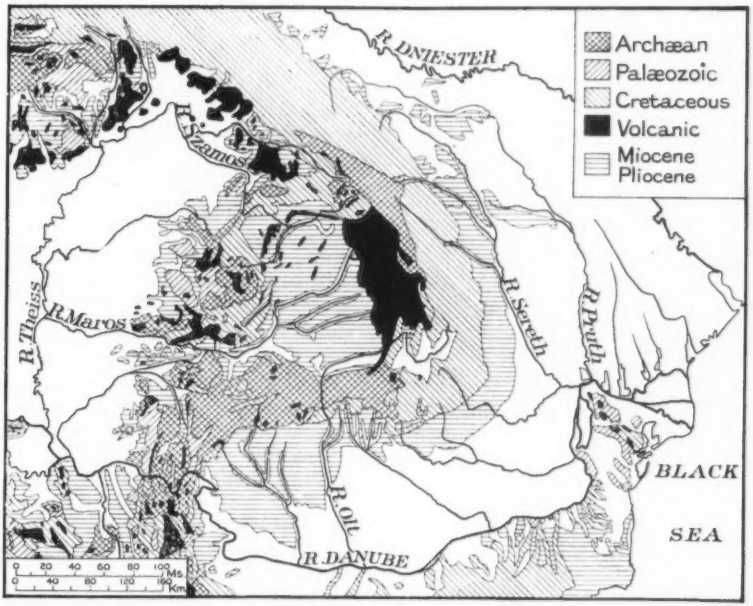
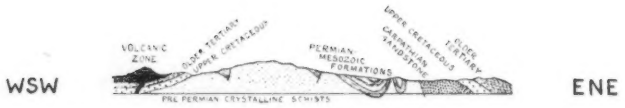
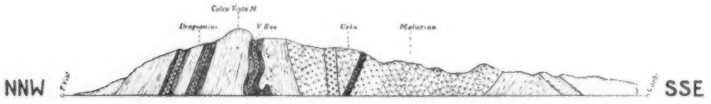


Fig. 2.—Geological Sketch-map of Transylvania



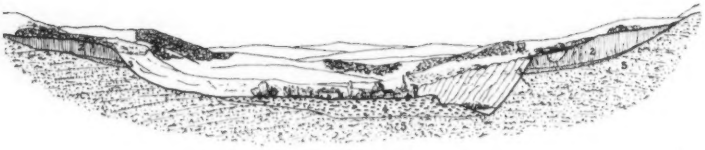
SECTION ACROSS EAST CARPATHIAN Mts AFTER V. UHLIG



SECTION ACROSS TRANSYLVANIAN ALPS (S CARPATHIANS)
AFTER G PRIMICS

GNEISS · AMPHIBOLITE-SCHIST · GRANITE · EOCENE
MICA SCHIST · CALC SCHIST · ERUPTIVE ROCKS · NEOGENE YOUNGER TERTIARY

FIG. 3



VALLEY OF THE MIRISZLÓ.

1. RED CLAY. 2. LOESS. 3. GRAVEL. 4. HOLOCENE DEPOSITS. 5. LOWER PLIOCENE.

FIG. 4

AFTER PAVAI-VAJNA

where the Maros River now leaves the country. The higher ground surrounding the central area of Transylvania on all sides is composed of older crystalline and early sedimentary rocks and forms the edges of the Transylvanian basin (Figs. 1 and 2).

The subterranean movements east of the Alps culminated in the great Tertiary volcanic outbursts of East and West Transylvania, as elsewhere on the flanks of the Carpathian range. It is these great deposits of lavas and tuffs which have formed the range of hills (Kelemen Hegyseg, Görgeny, Hargitta, etc.) which extends along eastern Transylvania in a direction parallel to, but more or less separated from, the main Carpathian range (see Figs. 1 and 2). Similar volcanic rocks exist in the west, where they help to form the mountain ranges of the Bihar, Gyalu, and other mountains which lie to the south-west of Kolozsvar, between the central depression of Transylvania and the great plain of Hungary. It is in these western mountains that we find the rich deposits of ore which have caused the Transylvanian gold-mines to be the most valuable in Europe. Here also is one of the few places in which that rare metal tellurium is found. The hot springs of Transylvania are intimately connected with these old extinct volcanoes.

All the central part of Transylvania is occupied by the deposits of Miocene and Pliocene times, more or less disturbed by subsequent earth-movements. In these deposits the modern rivers have cut deep valley grooves, causing the floor of the Transylvanian basin to present an alternation of ridges and furrows with but few intervening plains, a condition of things widely different from that of the great flat monotonous plain of Central Hungary. The scenery of central Transylvania may be described as comparatively tame. The accompanying semi-diagrammatic section across the Miriszló valley in the west central region (Fig. 4) gives a good general idea of this scenery. It is towards the periphery of the land among the broken and wooded ranges of mountains that we find the picturesque scenery of the country. Amid the worn-down remains of the great crystalline axis, in the deep gorges cut by rivers through Carpathian sandstone or Jurassic limestone, or among the dissected remnants of the great lava-flows do we look, and not in vain, for the singular natural beauty of the land.

Boundary-dykes.

In the earlier centuries of our era, and even before this, it was the custom among many nations and tribes to mark the limits of their land by huge boundary-dykes consisting of a great wall of earth with a ditch on the outer side. Thus, Tacitus relates that in the first century A.D. the Angrivarii were engaged in putting up a boundary-dyke against their neighbours the Cherusci, tribes situated to the east of the lower Rhine. Several of the boundary-dykes in the Balkans have been attributed to the Bulgarians of a later date (see J. B. Bury, 'Eastern Empire,' 1912, p. 338,

for an account of these). There are many similar boundary-dykes in our own country; of these the best known are Offa's, separating Anglo-Saxon Mercia from Celtic Wales, and Wansdyke, which excavation has shown to be of Roman or post-Roman date. Within 40 miles of London are two such dykes (the Buckinghamshire and Middlesex Grim's dykes), the age of which has never yet been seriously investigated, as they could be, and ought to be, by scientific excavation.

The land surrounding Transylvania abounds in similar dykes, marking doubtless the territorial limits of various nations. The great earth wall (Fig. 6) which runs across the Dobrogea from Axiopolis (near Cserna-voda) to Constantsa (the ancient Tomis, where Ovid spent several years in exile) has its fosse to the north, and, with its chain of camps, was apparently Roman. This, and the accompanying stone wall of later date and undoubtedly Roman construction, may be compared with the earth and stone walls of Roman times which run from Newcastle to Carlisle in our own country. But whereas our own Roman wall stands in many places still several feet in height, its Dobrogean contemporary, situated in a land where stone is scarce, has long been destroyed. Nothing now remains above ground save loose fragments of stone which form a conspicuous white streak, by which its course may easily be traced. The photograph in Fig. 9, taken from the ruins of Roman Axiopolis, shows well the steppe-like nature of the Dobrogea, and in the distance near the horizon the white line of the Roman wall is just visible. Roman perhaps are the two dykes that run east and west through Wallachia, the fosse being to the north of the vallum. Others, such as the "little" earth wall in the Dobrogea and that which runs through Tecuci in Moldavia, both of which I have had the opportunity of examining, were clearly erected by some more northern nations, since the fosse lies to the south. The dyke at Tecuci is known locally as Trajan's wall; but the name of Trajan is erroneously attached to antiquities in Rumania as freely as that of Cæsar is to those of our own country. Not only is the fosse to the south, but the irregularity of its line suggests barbarian work rather than Roman work of a good period. The breadth of the fosse in this part of its course (about 40 feet) is similar to that of the Buckinghamshire Grim's dyke.

It is but little I can tell you of these dykes on Tocilesco's map or of the people who erected them. But I have thought it well to draw attention to them in the hope that some of my audience may be able to tell us more about them. It is possible, too, that some future geographer may find them useful as a guide when tracing the boundaries of some of the early tribes who inhabited the regions which they delimit.

The Inhabitants of Transylvania—Rumanians, Hungarians, Saxons.

Having attempted to describe the physical and geological aspects of the land, I turn now to the inhabitants of Transylvania. A glance at an

ethnographical map, or an examination of official Hungarian population statistics, brings out at once the dominant fact that Transylvania, although a part of Hungary, is inhabited mainly by Rumanians and not by Hungarians. Of the two and a half millions of inhabitants, not less than five-ninths, that is more than half, speak Rumanian, while only three-ninths are Hungarian, the remaining ninth being Germans, generally known as Saxons.

On the first occasion on which my wife and I visited Transylvania, in 1896, the prominence of the Rumanian population was brought home to us in a striking manner. We had taken a long walk across the lower slopes of the Gyalu Mountains to the south-west of Kolozsvar, in the north-west of the country, far from the Rumanian frontier. We arrived about mid-day, hot, tired and hungry, at a village. No inn was to be found, so we began to ask, in our best Hungarian, where we could get something to eat and drink. But to our surprise we found that nobody could speak or understand Hungarian. Every one spoke Rumanian, a language of which we at that time unfortunately knew nothing. At last a small child was produced who at school had learnt some Hungarian. She knew, I think, about as much as we did ourselves, which was not very much. However, she could understand us, and, acting as interpreter, took us to the house of some friendly peasants, from whom we soon obtained a good meal of bread and milk. We were rather surprised at seeing in the place of honour on the wall a portrait of a king, not the King of Hungary, but King Charles of Rumania, and one of the first questions our hosts asked us was, had we been to Bucharest? It was evident that the interest and allegiance of these people living far off in Transylvania was centred, not in Hungary, but in distant Rumania.

I propose now to trace very briefly the historical development of these three nations of Transylvania—Rumanians, Saxons, Hungarians—and to show how large a part the geographical structure of the country has played in the development of its history.

Rumanians.

Passing over the earliest inhabitants of the land, of whom very little is known, we will begin with the Dacians, who before the time of Christ occupied not only what we call Transylvania, but also much of the surrounding country lying between the three rivers Dniester, Danube, and Theiss. Towards the end of the first century A.D. the Roman Emperor Domitian waged an inglorious war with the Dacians, who, among other exploits, completely annihilated one of his armies. Trajan, however, in his two Dacian wars, carried on in the early years of the second century, thoroughly defeated them and converted Dacia into a Roman province. A Roman province it remained for nearly a hundred and seventy years. The story of Trajan's campaigns is well known, and is well illustrated by the famous column in Rome, the sculptured reliefs on which tell us

so many details of the war. Less known, however, is the Trajan monument, or rather group of monuments, in the Dobrogea, which we visited in 1910. These deal not only with Trajan's but also with Domitian's wars. The archæological investigation of these monuments has at last thrown light* on a hitherto unsolved problem, namely, why did Trajan raise a noble monument so far away as the Dobrogea, and what became of Domitian's army which, with its general Cornelius Fuscus, marched against the Dacians and was never heard of again? Far away in this dreary land, not many miles from the Black Sea, stand the remains of a huge trophy from which have been recovered many sculptured slabs illustrating Trajan's campaigns. By its side are the remains of a funeral monument erected to the memory of some 4000 of Domitian's soldiers and their general Fuscus. It is now clear that the Dacians drove the Romans far to the east, and that it was in the Dobrogea and not in Dacia proper that Domitian's general perished. It was on the spot where he was defeated that Trajan, after his victorious wars, erected his trophy dedicated to Mars the Avenger, to show the barbarians that although they might by chance defeat a Roman army they could not do so with impunity, but that retribution would surely follow. The sculptures, now at the University of Bucharest,† show Trajan himself on horseback, the Roman legionaries and auxiliary troops, fights with Dacians, a Dacian waggon fortress, captives tied to trees, Dacian women and children, and many other incidents of the campaign. The portraits of these ancient Dacian women (Fig. 11), sculptured in the second century, probably locally by Trajan's soldiers who were well acquainted with them, show a remarkable facial resemblance to many of the women of modern Transylvania, as shown in Fig. 12 and in several others of my photographs. Near the monument is the modern village of Adam Clissi, where the Rumanian Government has been excavating the ruins of a Roman town (Tropœa Traiana) founded by Trajan and restored by Constantine. Both town and monuments were destroyed, probably by the Goths in the third century and later.

After Trajan's wars Dacia became a flourishing Roman province. To repopulate the devastated country Trajan is reported to have introduced 240,000 colonists "from all parts of the Empire" with the exception of Central Italy. As in contemporary Britain, the Romans made roads, built towns, erected temples, baths and other buildings, and developed the salt and gold mines. It is interesting to note that Dacia was the last province to be added to the Roman Empire, and the first to be separated from it. Acquired in 107 A.D., nearly three-quarters of

* We are indebted chiefly to the labours of the Rumanian archæologist Tocilesco ('Fouilles et recherches archéologiques en Roumanie, Bucarest,' 1900) and the German historian Cichorius ('Die römischen Denkmäler in der Dobrudscha, Weidmann': Berlin, 1904) for the elucidation of these problems.

† At least they were there when I last saw them, before the present war.

Fig. 5.—The gorge of the Danube below Moldava, entrance of second defile

Fig. 6.—The great Earth Wall: Ancient boundary dyke at Cochirleni near Csernavoda in the Dobrogea, looking east

Fig. 7.—Boundary pillars in the Cserna Valley, near Herculesbad. Rumania to right, Banat of Temesvar to left

Fig. 8.—The Szechenyi Road, left bank. Gorge of the Danube near Bazias, Banat of Temesvar

Fig. 9.—In the Dobrogea, looking east from the ruins of Axiopolis, near Csernavoda. The white streak slanting up to the horizon in centre is the remains of the stone wall, once the northern boundary of the Roman Empire

a century after Britain (43 A.D.), Dacia was relinquished by Aurelian (270 A.D.) owing to pressure from the Goths, nearly a hundred and fifty years before Honorius gave up the more northern province.

Barbarian Invasions.

For several hundred years after the withdrawal of the Roman officials, the lowlands north of the Danube, and to some extent south as well, were occupied by a succession of more or less barbarous peoples, Goths, Gepids, Huns, Avars, Slavs, and Bulgars, most of whom, all in fact except the last two, came and went without leaving behind them any marked or durable impress of their stay. These barbarian invasions affected chiefly the more accessible and more fertile lowlands. Some invaders, such as the Avars and Huns, appear to have swept round by the north, as did the Hungarians at a later date. But the main path of invasion into the Danube area was then, as it has been ever since, by way of the narrow passage between the Carpathian Mountains and the Black Sea, where Moldavia joins Wallachia and the Dobrogea. Here the steppe lands of South Russia are continuous with the similar country which lies on either side of the lower Danube, and the path of the invader is barred by no great physical obstacle. Transylvania in these times lay like a wooded and rocky island in the midst of a stormy sea of barbarism, the waves of which swirled round it, but only now and then broke over it. Gepids, Huns and Avars invaded what is now Central Hungary; Goths, Slavs and Bulgars preferred the lowlands of what is now Rumania. To what extent the barbarians crossed the wooded mountains and penetrated into Transylvania itself it is difficult to say. There can be no doubt however that the remote mountain valleys of the Carpathians afforded a secure retreat to many inhabitants of the plains who fled before the invaders.

Twice has it occurred to me in the last four years (once in Serbia and once in Rumania) to witness the flight of a civilian population before an invading army. Again and again in the course of mediæval Balkan history does one read how, as the enemy swept through the land, burning and killing as they went, the civilian population fled to the mountains. It is easy therefore to understand what happened to the inhabitants of the plains of the lower Danube as the hordes of invading Slavs and Bulgars pressed forwards. Some fled south to Macedonia, where the Macedo-Rumanians still exist; some fled northwards to the Carpathians. The great Slav invasions of the sixth and seventh centuries drove a permanent wedge between the Romanized inhabitants of the Balkan Peninsula and those of what had been Roman Dacia, and that Slav wedge has to this day never been withdrawn, although it has undergone some slight modification by fusion with the later Bulgar invaders. The modern Bulgarian, however, is mainly Slav by descent and speaks an almost purely Slav language differing but little from Serbian.

How far the Rumanians are direct descendants of the Daco–Roman inhabitants of Transylvania is an interesting and highly controversial question into which it is useless to enter here at any length. The broad fact remains that we have in the Rumanians of Transylvania a people speaking a language closely akin to Latin and quite different from the Slav, German, and Hungarian languages by which they are surrounded.

What became of the Roman colonists after the withdrawal of the Roman legions in 270 is uncertain. That some of them retired with the Roman officials to Moesia there is no doubt. That anything like the majority of them did so, is in the highest degree improbable. Nor is it in the least likely that the original Dacians were wholly exterminated by the Romans, as some authorities maintain. When a conquering army or nation enters a country which consists partly of mountains and partly of lowlands, what usually happens is that the invaders settle in the more fertile lowlands while the original inhabitants take to the hills. This is what happened in our own country when the invading Anglo-Saxons drove the original Celtic inhabitants to the mountainous regions of Wales, Cumbria and Scotland. If we look at an ethnographical map we see that the Rumanians occupy, not only the whole of the mountainous ring of outer Transylvania, but extend in all directions around it. This is not the situation in which we should expect to find their settlements had this people spread upwards from the south at a later period, as some authors have sought to maintain. But it is just the situation in which we should expect to find them if they were the descendants of the original inhabitants driven from the centre towards the surrounding hills by subsequent invaders who took possession of the more fertile centre of the country. Nor does the evidence of place-names wholly fail to show the continued existence of a Rumanian-speaking people in Transylvania. It is true that a very large number of village names are Slav rather than Rumanian and owe their existence to later invaders, yet there are others that betray a Rumanian origin. Far away to the north, beyond the borders of modern Transylvania, on the banks of Szamos, near the point where that river forsakes the hills and enters the great Hungarian plain, lies a town bearing the Rumanian name of Satu mare or Great village. This name appears on most maps disguised under its equivalent Hungarian spelling of Szatmar. The town is an ancient one, since a document of 1230* states that Queen Gisela of Hungary (wife of St. Stephen, 997–1038) brought Bavarian colonists to Zathmar Nemety (or Zathmar "of the Germans"). It is interesting to notice that eight centuries ago the words for "great" and "village" had already assumed practically the same forms that they now have in modern Rumanian. Now the Rumanians speak a Latin language, a language which although containing elements

* Fejer, 'Codex diplomaticus,' III. 2, p. 24, quoted by Xenopol, 'Hist. d. roumains,' p. 149 (Leroux, Paris).

of Slav and other tongues, yet is more closely allied to Latin than to any other of its derivatives except Italian itself.

The close affinity of Rumanian to Latin and modern Italian is well illustrated by the following table of common words, which might easily be greatly extended:

English.	*Modern Italian.*	*Latin.*	*Rumanian.*	*Slav (Serb).*	*German.*	*Hungarian.*
Water	Acqua	Aqua	Apa	Voda	Wasser	Viz
Eight	Otto	Octo	Opt	Osam	Acht	Nyolcz
Night	Notte	Nocte(m)	Nopte	Notj	Nacht	Éj
Milk	Latte	Lacte(m)	Lapte	Mleko	Milch	Tej
Bread	Pane	Pane(m)	Pane *	Hleb	Brod	Kenyér

A remarkable feature of Rumanian is the use of the consonant *p* where in Latin we should find a *q* or *c* (*k*), and especially when *c* occurs before *t*. In this respect Rumanian bears the same relation to Latin that Gaelic (Scotch and Irish—*q*-Celtic) does to Cymric (Welsh and Breton—*p*-Celtic), and that Roman Latin does to some of the ancient provincial Italian languages, *e.g.* Oscan (*cf.* Roman Quintus = Prov. Ital. Pontius, as in *Pontius* Pilate).

Does this use of *p* in modern Rumanian indicate that the Daco-Roman colonists came from the extra-Roman provinces of Italy, or does it point to some very different connection with extra-Italian races?

There is no evidence to show that any considerable immigration of a Latin-speaking race ever took place into Transylvania after the period of the Roman conquest of Dacia. There can be no doubt that the inhabitants of Transylvania have spoken a Latin dialect ever since Roman times. The only alternative to the supposition that Rumanian is derived from the Daco-Roman colonists is that the language descends from that of some still earlier inhabitants of Dacia—some primitive people speaking a language akin to, but not actually derived from, Latin. But this question is mainly a philological one which is difficult to answer without more knowledge of the Dacian language than we at present possess. The main point which can hardly be disputed is that the present Rumanian-speaking people of Transylvania are the survivors of the earliest inhabitants of which we have any definite historical record, and that they have been settled in the country from the earliest times until the present day. There is documentary evidence that large numbers of them, in order to retain wealth and privileges, gradually underwent a process of Magyarization and became fused with their Magyar conquerors. A similar process took place in Bosnia after the Turkish conquest, many Bosnians adopting the Mohammedan religion and becoming known as "Turks," the name by which these Slavs are still known in Bosnia at the present day. There is this difference, however, that whereas those of the Daco-Romans who became Magyarized adopted the language of their conquerors, the

* Pronounced nearly as "pweeny."

Bosnians adopted the religion only, in most cases retaining their native language. The Bosnian "Turk" of the present day usually speaks Slav.

Saxons.

The history of the Germans or Saxons in Transylvania is comparatively simple. We all know the picturesque legend of the Pied Piper of Hamelin, which tells us that the children enticed away by the piper reappeared in distant Transylvania. The historical kernel of truth in this legend is the fact that in the twelfth century the King of Hungary invited numerous colonists from western Germany to settle in the country, granting them land and special privileges in order that they might defend the border against the savage Kumans, who at that time occupied what is now Rumania. A little later another Hungarian king invited the Teutonic knights to settle in the Burzenland, the fertile plain in the extreme south-eastern corner of the country. This king Andrew, like his contemporary, our own king John, had his troubles with the turbulent nobles. The latter complained that the king favoured the foreigners. They succeeded in wresting from him the Golden Bull of privileges (1222), only seven years later than the date of our own Magna Carta. Soon afterwards the Teutonic knights left the country and migrated to Prussia, where they laid the foundations of that state whose arrogance and ambition have been the principal cause of the present war.* But the other Germans remained, occupying chiefly the southern portions of the country, where they founded, or refounded, the towns of Sibiu (Hermannstadt) and Brasso (Kronstadt). The favour shown to them by successive kings caused them, as in other countries, notably France and England, to be supporters of the royal power against the unruly and turbulent nobility. Whereas the Roman colonists had settled chiefly in the valleys and on low eminences, the Germans placed their fortified settlements on the tops of high hills, especially among the foothills and on the slopes of the mountains towards Wallachia and Moldavia. Traces of some three hundred of these fortified German settlements are said to be still in existence.

Thus arose the well-known "Bauernbürgen" or citizen fortresses, which differed from most of the fortresses of Western Europe in that they were in the possession of the citizens, and not, as for instance in the Rhine valley, of the nobles. As a typical example of a Transylvanian citizen fortress let us take that of Rosnyo (Rosenau), not far from Brasso and on the way to the Törzburg Pass. Here on the top of a high limestone hill

* In the cathedral at Königsberg, some fifty years ago, was discovered, under a coat of whitewash, an interesting early fourteenth-century fresco depicting the Teutonic knights in the dress of the period, about a hundred years after they had quitted Transylvania. A coloured reproduction of this fresco has been published by Wilhelm Bergmann in his 'Reste Deutscher Ordensburgen in Siebenbürgen,' publ. W. Krommer, Freudenthal, Austrian Silesia, 1909.

Fig. 10.—The Fortified Church at Keresztenysziget (Grossau), South Transylvania

11.—Dacians from the Adam Clissi Monument, Dobrogea

Fig. 12.—Peasant Woman of South Transylvania

Fig. 13.—Historical Sketch-map of Transylvania

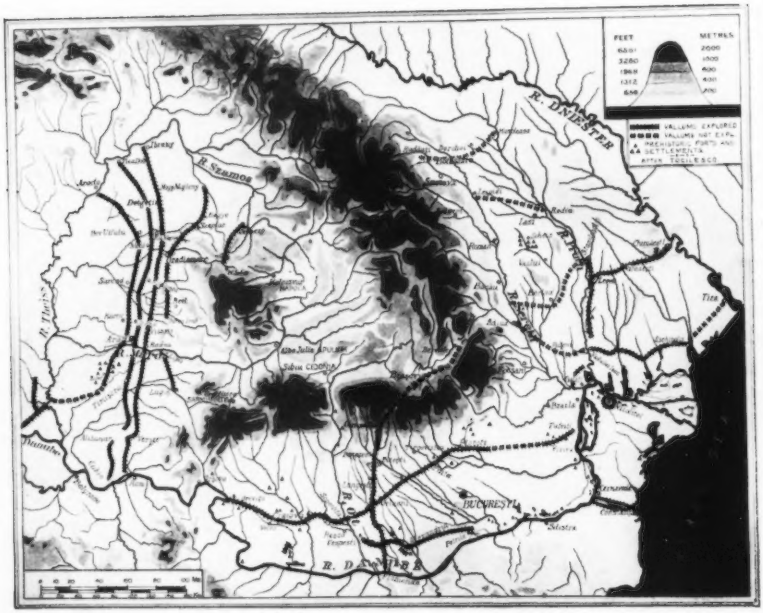


Fig. 14.—Boundary Dykes in Transylvania

are the ruins of the old town, surrounded by crumbling walls, while some 500 feet below, in the plain, is the modern town of the same name. In times of danger, which were frequent enough in the neighbourhood of the Törzburg Pass, the whole population could take shelter behind the fortified walls of the hilltop.

The Fortified Churches of South Transylvania.

An interesting and remarkable feature of South Transylvania is the wonderful series of fortified churches, to which I now turn. Not only were towns and villages fortified, but in many cases the churches themselves. Massive walls 25–30 feet in height, with lofty towers and frowning bastions surrounded the ample churchyards. Within the walls capacious storehouses were kept well filled with weapons, ammunition, and provisions. The churches themselves, with small windows, few entrances and often double roofs, had external galleries, embrasures, loopholes and other arrangements for defence. Sometimes (as at Heltau, near Hermannstadt) a double or triple line of wall surrounds the churchyard, and even at the present day the churchgoer obtains access only by passing through a complicated series of zigzag entrances and passages, commanded by the loopholes of the defenders. Of those that we have personally visited, Nagy Ajto has high enclosure walls with large angle bastions; Keresztenysziget (Grossau) (Fig. 10) preserves its high wall, provided with fortified entrance and towers at intervals, as also does Kerestenyfalva (Neustadt); Birthelm has more than one enclosure wall with entrance passages between them; Heltau had three walls (of which one has now been destroyed), and a complicated zigzag entrance passage; Apold and Kis Kapus have fortified steeples with external galleries, from which the defenders could shoot. One of the finest is that of Baromlaka (Burmloch), with two massive steeples provided with protected external galleries for marksmen, while the north entrance to the church still retains *in situ* its heavy wooden portcullis. Some of these churches have double roofs, the intervening space being capable of containing a large body of defenders.

For seven and a half centuries the industrious and sturdy Saxon population of Transylvania has lived its life in this remote corner of the empire, always jealous of its privileges and ready to fight for them. Most of the industries of the country is in their hands. They have but little love for their proud and somewhat overbearing neighbours the Magyars, but combine with them in despising and oppressing politically the less fortunate Rumanian peasantry. For centuries, and until quite recent times, all political power was in the hands of the three "privileged nations." But these three were the Saxons, Magyars, and the Szeklers, and did not include the Rumanians, although these actually formed the majority of the inhabitants. Various attempts have been made by the Rumanians of Transylvania and of the neighbouring Rumanian countries

of Hungary proper to obtain full political recognition, but hitherto without avail.*

Szeklers and Hungarians.

The Szeklers are a Magyar-speaking people who occupy, in a fairly compact mass, the three counties of Csik, Háromszek and Udvarhély, in the south-east part of Transylvania. Their origin is uncertain. According to legend they are Huns who fled hither in the fifth century during the civil war that followed upon the death of Attila. Another and better view is that they are a branch of the Magyars who entered the country before the main body of invaders, crossing the mountains directly from the plains of Moldavia, perhaps through the Oituz Pass. At present this people is mixed both with later Magyar immigrants and with Wallachs who have become Magyarized, that is who have adopted the Magyar language, although still calling themselves Olah, *i.e.* Wallach.

All over Transylvania are found village place-names containing the prefix *Olah*, meaning Wallach or Rumanian. Thus Olah Ujfalu (in the county of Fogaras) in the valley of the Olt; Olah Dalva, Olah Szilvas and Olah Peterlaka (Co. Also-Feher), Olah Kocsard and Olah Salyi (Co. Kis Küküllö), Olah Brettye (Co. Hunyad), Olah Nadas (Co. Maros Torda), Kapolnas Olahfalu and Szentegyhazas Olahfalu (both in the Szekler county of Udvarhely), and another Olah Ujfalu (Co. Kolozs), all in the basin of the Maros; Olah Lapos (Co. Szolnok Doboka), Olah Gyeres (Co. Kolozs), Olah Szent Györgyi (Co. Bistritz Naszod), all in the basin of the Szamos.

Sometimes we find pairs of villages of the same name but with different prefixes, as Olah Lapos and Magyar Lapos, Olah Brettye and Magyar Brettye, and so on.

It is worthy of note too that the modern Hungarian words for "Italian" and "Italy" are "Olasz" and "Olaszorszag."

The Magyars themselves came from what is now known as South Russia, and crossing the Carpathians in the ninth century by one of the northern passes, probably the Vereczke, between Stry and Munkacs, quickly overran the great plain of Hungary. But it was apparently not until a century or two later that the Magyars penetrated into Transylvania itself.

The political condition of the latter country in the ninth century is shown by the accompanying map (Fig. 1). East of the river Theiss we hear of three duchies, ruled by Dukes Menumorut, Glad and Gelu, of Vlacho-Bulgarian origin. Of Menumorut it is recorded that when summoned by the Magyars to give up his duchy he bluntly refused. But eventually his only daughter married a Magyar noble and the duchy

* Those who desire further information on this most interesting subject are recommended to study Dr. Seton-Watson's monograph, 'Rumania and the Great War' (Constable, 1915). It contains also full details of Hungarian official population statistics and an excellent ethnographical map.

passed into Magyar hands. A century later we hear of a fourth duchy, that of Kean, a shadowy duke who appears to have ruled in South Transylvania. In the eleventh century appears Duke Gyula of Transylvania, of whom much more is known. He appears to have been at first almost independent, but after his rebellion the country passed more definitely into the hands of the Magyar invaders. It still retained its ancient laws and privileges and was ruled by "voivodes," or dukes, of its own.

The map shows us also the routes pursued by the Tatars in their great invasion of 1240–1241 under Batu Khan. A description of this invasion by a Persian chronicler, Fazel-Ullah-Raschid, of the fourteenth century, based upon original Mongol documents, together with accounts given by early Hungarian and Byzantine chroniclers, gives us glimpses of the geographical position of the Rumanians or Wallachs, as they were then called, in the thirteenth century. Various little communities of these people were existing on the outer, that is eastern and southern, slopes of the Carpathians. Particularly worthy of notice is the territory of Bassaram Bam, as the Persian chronicler calls him, who is doubtless no other than the "Ban" or "Ruler" Bassarab, of the well-known Wallachian family which in later times gave so many princes to that country.

Rise of Wallachia and Moldavia.

Towards the end of the thirteenth and beginning of the fourteenth centuries, these little communities were increased by immigrants from Translyvania, both north and south. These, under historical leaders, crossed the Carpathians from Fogaras and Maramaros respectively, and founded the states of Wallachia and Moldavia.

The gradual development and territorial extension of these two principalities is shown by the gradual shifting of the capitals in succession from Cimpulung to Curtea d'Argès, Tirgovishtea and Bucharest, in the case of Wallachia; from Suceava (now in the Bukovina) to Jassy, in the case of Moldavia. In each case the position of the capital shifts from north to south. Both these principalities, at first independent, soon fell more or less under the power of the Ottoman Turks,* although still retaining their native princes and a large measure of independence.

Transylvania's Period of Independence.

Early in the sixteenth century,† after the conquest of Hungary by the Turks, Transylvania became free from Hungarian overlordship, and, although occasionally paying tribute to the Turks, was practically independent, and so it remained for more than 150 years.

It was during this time that Transylvania's territorial expansion was

* Wallachia first paid tribute to the Turks in 1391, Moldavia in 1456.

† After the great battle of Mohacs (1526).

at its maximum, embracing not only what is now Transylvania, but also a large tract of country drained by the upper Theiss as far as Kassa. At this time Transylvania rose to the rank of an important European power, making an alliance with Sweden and attacking Poland. It was during this period, however, that for a brief space (about a year) Transylvania was overrun and conquered by the Wallachian Prince Michael the Brave, who succeeded in uniting temporarily the three countries Wallachia, Moldavia and Transylvania (1599–1600).

Austrian Dominion.

Later still, at the end of the seventeenth century, after the defeat of the Turks by Austria and the evacuation by them of all Hungarian territory except the Banat of Temesvar, Transylvania fell under the dominion of Austria. Her native rulers nevertheless remained for a time, and she continued to retain a large amount of autonomy. In the meantime Wallachia and Moldavia had fallen more and more under the heel of the Turk. The condition of both countries in the eighteenth and early nineteenth centuries, when they were ruled by Greek governors appointed by the Porte, was one of great degradation and misery.

From the time of the Greek war of independence (1821), both Wallachia and Moldavia began to recover their liberty, until finally in 1859 both principalities were united under one ruler, in spite of the opposition of the Great Powers, including Great Britain. A few years later all vestiges of Turkish sovereignty were shaken off, Rumania proclaiming her independence in 1877 and becoming a kingdom in 1881. The territorial changes which have occurred in the two principalities since their first foundation have affected Moldavia more than Wallachia. In the seventeenth century for a space of about twenty years (1718–1739) Little Wallachia (that is, Wallachia between the river Olt and the Banat of Temesvar) was lost to Austria but subsequently restored. The Bukovina was taken from Moldavia by Austria in 1777. Bessarabia was taken from Moldavia by Russia in 1812; the southern part only was returned to Moldavia in 1856, as the result of the Crimean war, but lost again in 1878 after the Russo-Turkish war. It is probable that the recent Great War will result in great alterations in the map of Rumania, but this is a political question upon which it is not right that I should enter here. As a purely geographical matter, however, I may point out that the "rectification" of the Hungarian–Rumanian boundary imposed by the Central Powers upon Rumania after the temporary defeat of the latter would have placed practically the whole of both slopes of the Carpathians in the hands of Hungary. As it is the boundary lies in many places, as I have shown already, on the Rumanian side of the divide. The suggested alteration would place the whole mountain range in Hungarian hands.

I have already spoken of the mixture of races and of languages in

Transylvania. An ordinary ethnographic map scarcely suffices to bring out sufficiently the intermingling which exists. Nor must it be forgotten that density of population must be taken into consideration when studying an ethnographical map, or wrong conclusions may easily be drawn. Most of the mountainous area of Transylvania, inhabited almost entirely by Rumanians, is naturally less thickly populated than many of the valleys of the centre, in the towns of which Magyars and Germans are prone to congregate.

But if races and languages are mixed in Transylvania, very much more so are they in the Banat of Temesvar, where Rumanians, Hungarians, Serbs, and Germans jostle one another in almost inextricable confusion. In general terms it may be said that the eastern or mountainous half is mainly Rumanian, the western half is mainly Serb in the south, and the Magyar in the north-west, with many considerable areas of Germans. An illustration of the mixture is well afforded by an incident which occurred to us in 1910, as we were riding through a village in the south-eastern part of the Banat, that is the part that on an ordinary ethnographic map would be marked as purely Rumanian.

As we entered the village a man spoke to us in Rumanian. When we asked the next man in Rumanian where the inn was, we got no answer until the question was repeated in Hungarian, when he answered promptly enough, "Over the hill on the left." On reaching the spot indicated, a man at the door of the inn spoke to me in Hungarian. Entering the inn and asking two men there in Hungarian for the landlord, we got no reply until the question was repeated in Serb, for they knew no Hungarian. The landlord when he appeared spoke to me in German. All this within twenty minutes!

We afterwards had a long conversation with the two Serbs, and learnt that the village was considered to be a Serb village, although lying in an otherwise Rumanian district. The men who spoke Hungarian were probably officials.

If the linguistic boundary of the Rumanian-speaking people is difficult to define, it is otherwise with the physical western boundary of Transylvania. Here a great range of mountains, but poorly marked in many of our atlases,* extends due north from Deva on the Maros to the headwaters of the Swift (Sebes) Körös river. The line of mountains then passes in a north-easterly direction (by the Meszes and Lapos Mountains), crossing the Szamos where it makes its remarkably acute bend, to reach the main Carpathian range at the Rodna Mountains.

From this line the land slopes rapidly down to the west, the 200-metres (656 feet) contour line passing approximately from Ram on the Danube nearly due north by Temesvar and Arad to Nagy Varad (Gross-

* See an interesting correspondence on the question of the western boundary of Transylvania by Colonel Rosetti and the President in the November number of the *Geographical Journal.*

wardein). If the orographical map be compared with the geological, it will be seen that this line marks both the limits of the Pliocene sea of ancient times and those of the modern Central plain (Alföld) of Hungary, its dried-up basin. Linguistically the Rumanians occupy the rising land that once overlooked the Pliocene sea, the Magyars, Serbs, and Germans of the Banat occupy mainly the bed of that sea.

Let me conclude with the hope that the Peace Conference, which begins to-day, will find a satisfactory solution to the various difficult problems—racial, geographical, and political—which it will be called upon to consider when dealing with the future of Transylvania and its relation to Rumania, and with the remains of what was once Austria-Hungary.

Before the paper the PRESIDENT said: It is not often that we find any one well acquainted with a district in Europe which is so comparatively out of reach as Transylvania, and it is indeed seldom that we can find any one who has made a study of a remote country like that for a number of years, and is so well able to give us an account not only of the people but the country itself and its geographical disposition, as is Mr. James Berry. For many years he has travelled in that country, and he has much to tell us which is not only interesting but which will be exceedingly instructive at this particular crisis of European history. I will, therefore, at once ask Mr. Berry to commence his lecture.

(*Mr. James Berry then read the paper printed above, and a discussion followed.*)

Lord BRYCE: It is with great diffidence that I respond to the call of the President, because I feel how infinitely less I know about Transylvania than Mr. Berry, who has delivered to us this extremely interesting lecture. My knowledge of the country is also of rather ancient date. As some of you will remember, early in 1866 there was a great war between Prussia and Austria. Fired with a desire to see something of military operations, I proposed to my dear friend, Mr. Leslie Stephen, whose name is remembered by all Alpine climbers and by all lovers of literature, that we should go out to the scene of operations to see something of the fighting. We fortified ourselves with letters to leading persons on both sides, a somewhat dangerous proceeding. However, we were not arrested, and reached Vienna, but unfortunately just too late. The Prussian army was moving forward to the Danube and the preliminaries of peace had been concluded, so that there was no fighting to be seen. We fell in with an interesting Englishman who wrote a book about Transylvania, which probably Mr. Berry has read, in which he gave an excellent account of Transylvania as it was about 1850. Mr. Boner advised us to go to Transylvania. In those days there was no railway. One could travel by tram only as far as Arad, where we spent a most tedious day, in the middle of the vast Hungarian plain, dusty, and monotonous. The following day we had to proceed in a very small cooped-up little vehicle which they call a *Stellwagen* in which there was only room for four people, but in which we passed two days and two nights. We reached at last the little Saxon town of Hermannstadt and began wandering about Transylvania. Although there are a great many picturesque and interesting places among the Transylvanian mountains, particularly on the east and south, the scenery is not to be compared in grandeur to that of the Tatra in North-West Hungary whose mountains are granitic,

reaching nearly 8000 feet, lofty, and exceedingly steep and rocky; and the country is full of the most beautiful lakes and woods. When peace and order have returned to those regions and you wish to visit a little-known part of Europe, you will find charming scenery and mountains that afford extremely fine and difficult rock-climbing. The native population consists (with some few German villages) chiefly of that people interesting us so much now because they are establishing a republic of their own on the basis of the ancient kingdom of Bohemia, viz. the Czecho-Slovaks. I was taken up the Gerlsdorfer Spitz, the highest of those mountains, by a Slovak guide who was as nimble and adroit a climber as I ever met anywhere. He appeared to be able to walk like a fly up a precipitous rock, and I had to communicate with him in the only two Slovak words I possessed. If you ever like to visit Hungary you will find the Tatra an exceedingly interesting region for excursions.

As regards Transylvania, one of the things that most strike the traveller is the diversity of the various races that inhabit it. I remember how astonished we were, it being the first journey we had ever taken into Eastern Europe, to find three different races dwelling practically together upon the same ground, not speaking one another's language, belonging to different Churches, and having little or no sympathetic interest at all in one another. In fact, each rather disliked and distrusted the other two. At that time, however, they were not on such bad terms as they have more recently been. We did not hear complaints made by the Wallachs—as the Rumanians were then usually called—against the Hungarians and Saxons, but the Saxons or Germans were a little jealous of the Hungarians, the former being a small people whose numbers were dwindling. Families were getting smaller, and in every generation the number of Germans was becoming less. I recollect the replies we almost invariably received from the Germans, who even then were not noticeable for their too kindly views of other people, when we asked them about the Wallachs. "What sort of people are they?" we asked. "Well," they said, "a dirty people." "Anything more?" "A false people, a stupid people, a useless people. But after all that they are not such a bad sort of people." We formed the impression that the last statement was true. They were a very kindly, good-natured people; they always saluted us when we passed them on the road in the most cordial way, and did their best to make us comfortable. They were in those days very backward, with comparatively few educated people among them, but they lived upon good terms with the Saxons and Hungarians, and the bitterness which has given trouble in recent years had not then arisen. There are many disputes among all these East European peoples, as for example in Poland between the Ruthenians and the Poles, further south between Serbs, Greeks, Albanians, Bulgars, in fact all over the Balkan countries, and along the Adriatic, as to what are the true boundaries between the various nationalities. Our impression was that the Wallachs or Rumans made up about two-thirds of the inhabitants of Transylvania. But now they want the whole of it and a good slice of Hungary as well. Those demands seem to be exorbitant, and it will be—whether for the Paris Conference or for any Commission of Delimitation that may be hereafter established—an extremely difficult question to settle what lines of boundary they are to draw between the Saxons of towns like Hermannstadt and Brasso (which we called in those days Kronstadt), how to secure for each their local independence and autonomy, and similarly the local independence and autonomy of the Magyar or Hungarian part of the population which is scattered here and there in small areas and increases as one goes north-west to the frontiers of Hungary proper; and how to reconcile the rights of Magyars

and Saxons with the claims of the Rumanian people, which on the whole is the majority. Mr. Berry referred to one particular Magyar tribe called the Szeklers, who are an extremely interesting people. They speak a dialect of Hungarian, but they do not look quite like the ordinary Magyars in complexion and in the build of body. They are unlike the other Magyars in that they inhabit a mountainous country, the rest of the natives dwelling on the great plain.

We went to see a famous mineral spring called Borszek, which lies up on the eastern side of the country near the borders of Moldavia, and took a long day's walk over those mountains accompanied by a party of Szeklers. I never heard people talk so unceasingly. They are, like the other Magyars, men of a bold and vigorous character, with a good share of national pride. They are not very numerous, there being perhaps not more than 100,000 or 150,000 of them. It would be a very great pity if they were swamped in the Rumanian population that surrounds them. I hope whatever arrangement is made for the future political status of Rumania and Transylvania they will be allowed to remain as an autonomous people.

The Transylvanian Saxons are all Lutherans, the Hungarians mostly Roman Catholic, and the Szeklers the same, though among the latter there are many Unitarians. Most of the Rumans belong to the Orthodox Eastern Church, although some have accepted the supremacy of the Roman See. It is worth recalling that I never entered a country where there is so complete an absence of religious persecution and intolerance as in Hungary, and this seems largely owing to the extreme strength of Hungarian national feeling. Magyars have been contending for many years against the despotism of Austria and her desire down to 1868 to subdue Hungary. This strong national feeling has drawn together the Protestants and Catholics, and has prevented those antagonisms from which the rest of Europe has suffered. Without entering into the obscure ethnological questions which surround the origin of the Ruman people, I should like to make one remark with regard to the Roman occupation of Transylvania. At a town called Banya we saw gold-mines worked by the Romans in an exceedingly hard porphyritic rock. The Roman shafts and galleries can be traced, and the modern miner is still at work beside them. Long horizontal galleries have been driven into the rock, and the people in the streams still wash gold out of the sand just as was done in the earliest days. I suppose that is one of the most remarkable cases of mining continued in the same spot through many centuries under many different kinds of rule; all sorts of wild Asiatic tribes coming in this region one after the other, mastering the country and establishing their brief dominion from the days of Trajan down to invasion of the Magyars in the ninth and that of the Mongols in the thirteenth century. The origin of the existing Ruman people, how they came into Transylvania, is, of course, an extremely puzzling question. The theory that the Rumans themselves put forward is that they were the descendants of the Roman colonists who settled there in the days of Trajan; but physically they do not remind one of what we take to have been the old Roman type, although the Ruman women are equal in good looks to the North Italians, and are indeed the handsomest women you see anywhere in Eastern Europe. They have a well-moulded form, a good carriage, are often tall, and with very regular features. The better opinion seems to be that the Rumans are a native race, whether "Dacian" or Thracian, who learned Latin during the time of the Roman dominion, and who have retained it ever since. There are a large number of people speaking

Ruman who are scattered over the rest of the Balkan countries; here and through Macedonia, Bulgaria, and Southern Albania as far as Ochrid and in the wild recesses of Mount Olympus and of Pindus. These Ruman-speaking Kutzo-Vlachs are mostly shepherds, very largely nomad. How they came to preserve their individuality and retain what is, broadly speaking, the same language as that of the Rumans proper in the north is one of those mysteries that nobody has solved. The whole subject is extremely interesting, and tons of volumes have been written on it, but the puzzle still remains to be cleared up. If Mr. Berry could give us his views I think he would further add to the obligation under which he has placed us by this instructive lecture and by the pleasure we have all enjoyed in seeing the excellent slides. They remind me vividly of the singular fortified churches he so well described; but I must not detain you by entering into that subject. We shall carry away with us a very vivid recollection of Transylvania from the lucid descriptions and the admirable photographs with which he has illustrated his discourse.

The PRESIDENT: Some, if not all, of the excellent illustrations we have seen have been prepared by Dr. Dickinson Berry, whom I am sure you would all very much like to hear on this subject.

Dr. DICKINSON BERRY: There is one point on which I should like to say a few words, and that is the relations that have existed between part of Transylvania and England for many centuries, of whose existence I think very few people know. Lord Bryce spoke about the Szeklers as being Roman Catholic. They are very largely so, but there is a very considerable Protestant minority. I have not the figures, but this Protestant minority is not only considerable in number, but is probably stronger than the other sections in organization, position, and intelligence. In the early days of the Reformation a large proportion of Transylvania, especially the Szeklers (for the religious sects follow almost exactly the national divisions) became Calvinists, and during that time relations were entered into with Scotland, and students were sent from Transylvania to Edinburgh. A little later there was a very influential Unitarian preacher who converted the larger part of the Calvinists in Transylvania to Unitarianism, and the students were then sent to the Unitarian College which existed, first in London, and is now at Oxford. This has continued until the present day. We ourselves have had a Transylvanian student in our house a considerable time. It is greatly to be hoped that, whomever these people come under in the changes which will occur after the Peace Conference, they will be able to retain under the new regulations their present organization, their present development, and their own endowments.

Prof. A. KEITH, F.R.S.: Although not an expert on the Balkan people, I may be allowed to congratulate Mr. Berry on the successful manner in which he has placed years of experience before this meeting. Lord Bryce has told us that the Rumanian type, with straight, sharply chiselled nose, dark eyes and regular features, is not the same as the South European or Mediterranean type. To my eye, although I have not visited those people in their native districts, the Rumanian people, in spite of their round heads, are distinctly of the Mediterranean type. Historians and ethnographers who have written on the settlement of the Balkan Peninsula have been too much influenced by the beliefs which were prevalent in the pre-Darwinian period—namely, that a virgin world in a few thousand years had been overrun by horde after horde of various racial types. So far we know nothing of the Pleistocene races of the Balkans, but we may reasonably presume that for tens of thousands of years

the Peninsula has been inhabited, and that invasions and migrations have been taking place all the time. The present racial patchwork was a result of the ethnographic changes which had been going on for thousands of years past. We know of no case where an invading race exterminates a native race—save when a very superior racial type and civilization comes in contact with types which are markedly inferior. I agree with Mr. Berry that the two types he had recognized were representative of different racial stocks, but am not inclined to apply the name Alpine or Celtic to the dark type with the Mediterranean form of face. The flat, broad-faced people had, to a certain degree, Tartar or Mongolian affinities. I believe that Ripley's so-called "Alpine" or "Celtic" type was a congeries of different racial stocks, which were bracketed together because of the roundness of their skulls. Skull-form is only one feature, and must not be assessed at too high a value in determining the genetic relationships of races.

Mr. JAMES BERRY: In reply to Lord Bryce's very interesting remarks I should like to say I entirely agree with him in what he said about the Tatra Mountains differing from the Southern Carpathians in being somewhat higher and on the whole more rugged. Like him, I have climbed the Lomnitzer Spitze in the Tatra, and I remember that at that time it was supposed to be the highest peak, but another peak has since been ascertained to be a few feet higher. Besides the main mass of Rumanians inhabiting Transylvanian Hungary, there is a considerable number of Macedo-Rumanians in the southern part of the Balkan Peninsula. I should say that they must have separated from the Rumanians of Transylvania a very long time ago, because their language is so different. To express the same meaning they use words taken from different Latin sources. Thus for twenty the Daco-Rumanian uses the word *douazeci*, from the Latin duo-decem, while the Macedo-Rumanian says *gingitz* (Lat. viginti); for wind the former says *vint* (Lat. ventus), the latter *avra* (Lat. aura), and so on. There is also a third group of Rumanian-speaking people in the middle of Istria, where you find one or two small colonies of a few thousand Rumanians. How they got there I do not know. Prof. Keith's remarks are very interesting. I should like to have a long talk with him on the subject. According to Ripley (Races of Europe), there is a very remarkable change in the shape of the head as you pass from the Dobrogea, which is a long-headed region, to Transylvanian Hungary, which has one of the most round-headed races in Europe. Sufficient investigations have not really been made to enable us to draw conclusions, but the Mediterranean race Prof. Keith sees in the Rumanians I do not think he would see if he went into the villages of the Carpathians. I believe it is in these remote Carpathian villages that you find the original Rumanian race, and they have probably been there not for hundreds but for thousands of years. When invasions of the plains took place the invading people usually took the lowlands, the more fertile lands, and drove the people up into the highlands. This is what our own Anglo-Saxon ancestors did; they drove the Celts into Wales and themselves occupied the lower and better lands. That is what the Hungarians did when they settled in the central plain of Hungary. That is what the Slav did when he went into Rumania—he drove the people into the Carpathians. Invasion rarely involves complete extermination of the invaded population. From what I have seen of Serbian, Rumanian, Hungarian, German, and other peasantry in south-eastern Europe, I think they do not want to fight; they are mostly peace-loving people who want nothing better than to stay at home and cultivate their farms. I have known the Serbs since 1904, and a more good-tempered and good-natured people I have never met, and they are not people who want to fight, even with

the Bulgarians. Although they are naturally very sore now, I believe in a few years' time there will be a friendly feeling between the average Serb and the average Bulgarian. It is the rulers, not the peoples, who desire war, and so it has been throughout history.

The PRESIDENT: In bringing this exceedingly interesting discussion to a close I need hardly suggest what you must already have gathered, that an exceedingly knotty problem lies before the unfortunate Commission who have to settle any boundary on a racial basis in the west of Rumania. We have heard something of the complexity of the people, of the extraordinary admixture of languages that exists all along the border, and we know that, after all, within the limits of the countries which are to be included under one nationality there are really three or four nationalities, and it is only a question of who claims the majority. In the case of Transylvania it appears, from what Mr. Berry has said, that five-ninths of the people are Rumanians and four-ninths are either Germans or people usually classed as Magyars, and there is this difficulty about the Magyars: that the district which they occupy is wholly occupied by them. We are all of us exceedingly anxious to see Rumania get all she can for the assistance she has given us in this great war, and I think there is little doubt that she will not only secure to herself a northern frontier with the addition of Bukovina, an eastern frontier with the addition of Bessarabia, a southern frontier with the addition of the Dobrogea, and a western with the addition of Transylvania, which together will make her perhaps the most important and strongest of all the Balkan States of the future. That is what all of us, no doubt, devoutly hope may happen. But the question of delimiting a boundary between the different nationalities is one which will give rise to an immense amount of discussion and will certainly not be settled very readily or soon. What Lord Bryce said has informed me much on a subject about which I have hitherto obtained no really valid information, and that is who were the Vlachs or Wallachs? Lord Bryce evidently considers that the Rumans or Rumanians and Vlachs are the same people. I have seen it stated that the Vlachs are derived from a people who were in possession in pre-Roman times, and that they became Romanized. They have adopted the position of Rumans, and now the Vlachs or Wallachs, who are the people who have given their name to Wallachia, are reckoned as Rumanians, both in Wallachia also and Moldavia. But it seems to me, particularly from what Mr. Berry has said, that the Rumans of Transylvania are the real original descendants of the Roman colonists; that the true Rumanian is really Transylvanian, and that Wallachia and Moldavia are subsequent additions to the original Rumania. You will find all the world over that in the most inaccessible mountains the oldest inhabitants are to be discovered. It is true from the Kafirs of the Hindu Kush to the Illyrians of Albania. I think the oldest people of the Balkan States are probably the Albanians. They trace their lineage farther back than any other, and reckon themselves to be the descendants of the old Illyrians. They respect the Vlachs, and consider them to be a people of an ancestry, if not quite as old as their own, at any rate respectably old, and they admit of intermarriage between the Vlachs and themselves. Consequently, the Vlachs have appeared to me to be in a position distinct from the Rumanians or Rumans, the true descendants of the old Roman colonists of Dacia. As Lord Bryce has truly said, all this is more or less a mystery, but one which, I hope, will be cleared up sooner or later, because undoubtedly these people are the most interesting people with which we have to deal in the Balkans. There is one other point

to which I might refer in connection with this very interesting address, that you need not go quite so far as the Balkan States to find churches which are built for the purpose of defence. I have seen one in Wales, not very far from Llandrindod, that was distinctly built for defence in very ancient times when defence depended on the bow and arrow. I ask you to unite in a very cordial vote of thanks to Mr. Berry for one of the most interesting addresses we have heard here, and at the same time to thank those who have taken part in the discussion which has followed.

A TRANSFORMATION OF THE MAGNETIC DIP CHART

E. A. Reeves, F.R.A.S., Map Curator R.G.S.

Chart following p. 208.

IF we turn to any magnetic charts of the world showing curves of equal inclination or dip we must be struck at once with the great irregularity of these curves, and their apparent lack of symmetry. This is noticeable both in the northern and southern hemispheres, but especially in the latter, where they diverge in a most remarkable manner.

These equal inclination curves represent positions on the Earth's surface where the dipping needle, when placed in the magnetic meridian, comes to rest at the same angle with the horizon. The angles, however, are measured, not from any common datum that is constant for wherever the observation is taken, but from the horizon of the place; hence their great irregularity. The horizons not being parallel, equal inclinations to the horizon do not imply equal inclination to any common axis of reference; and for purposes of discussion curves of equal dip are not necessarily convenient.

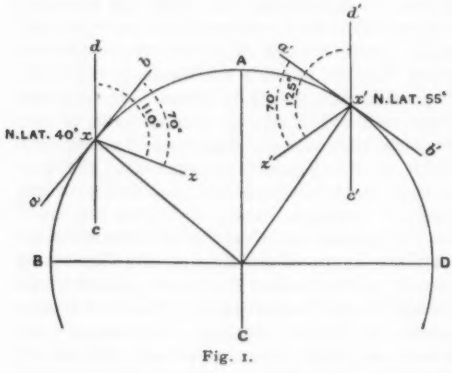


Fig. 1.

Suppose ABCD (Fig. 1) to be the true meridian, AC the geographical axis of the Earth, and BD the equator. Now at x in N. altitude 40°, suppose the inclination measured to be 70° below the horizontal; the position the needle will take will then be shown by the line xz, and the horizontal line by the line ab. Next, let another observation be taken on the same meridian, but on the opposite side of the pole, say at x', in N. latitude 55°, and again let the inclination measured be 70° below the horizontal, $a'b'$, the needle coming to rest in the line $x'z'$. In these two

places, then, the inclination as measured from the horizontal is the same, and the curve of 70° equal inclination is made to pass through them both; but the horizons from which the inclinations are measured are not parallel with one another.

It appears, then, that although inclination or dip may be most conveniently measured from the horizontal, it is important to remember that it is so measured, and that if referred to any common axis of reference the angles will no longer be equal or similar angles. For instance, let the line AC, the geographical axis, be taken as the basis of measurement, and *cd* and *c'd'* be drawn through the points *x* and *x'*, parallel with this line. Then, although in both cases the angle of inclination from the horizon line is 70°, it will be seen at once that when reduced to these parallels, *cd* and *c'd'*, at *x* the inclination will be 110° and at *x'* 125°. In fact, in this case *x* would have to be moved much nearer the geographical pole, A, before its axial inclination equals that of the station *x'*.

In order to ascertain what would be the result of reducing the inclination curves to a fixed axis of reference, the annexed charts of the Northern and Southern Hemispheres have been prepared from a large number of computations made in my spare time during the past few months. The first point to be considered was the most suitable line to be taken as the common axis. I had thought of taking a straight line joining the dip poles; but for several reasons this was soon found to be quite unsuitable. The so-called dip poles are not 180° apart in longitude, neither are they in similar latitudes in the north and south polar regions; consequently a straight line joining them would not pass through the centre of the Earth. Then again, the dip poles seem to bear little relation to the areas of maximum total intensity, which probably influence the direction taken up by the needle. There seemed no advantage in taking an axis such as Gauss' theoretical magnetic axis. I therefore decided that the most reasonable line to take as the axis of reference of the curves was the geographical axis of the Earth, or its axis of rotation, and the result has led to some interesting results which I think fully justify the selection I have made.

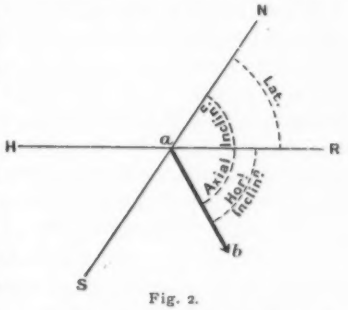


Fig. 2.

Referring now to the charts, the red curves run through the positions where the dipping needle comes to rest at the same angle with the geographical axis of the Earth; where the north-seeking end of the needle dips below the equatorial horizon, the angle is measured from the north end of the axis; and where the south-seeking end dips it is measured from the south end of the axis. To make this clear, suppose NS (Fig. 2) to be a line parallel with

the geographical axis, and *ab* a dipping needle which is freely suspended at *a*; the angle that the needle makes with the north end N of the axis is the angle N*ab*. At points on the Earth where there is no 'variation' this angle can be obtained at once by adding the latitude to the horizontal inclination or dip; but otherwise the declination of the needle must be allowed for, and the angle can only be obtained by spherical trigonometry, as follows:

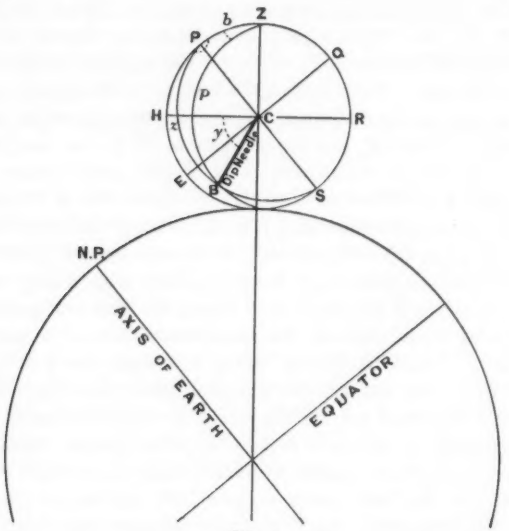


Fig. 3.

In the spherical triangle PZB (Fig. 3) PS is a line parallel with the axis of the Earth, Z the zenith, and HR the horizon line. BC represents a dipping needle at the angle y below the horizon. The side ϕ is then $90° + y$, the side b equal to the co-latitude of the place, and the angle at Z that the side b makes with the side ϕ (shown by Z in the computations) the angle of declination of the needle, or the variation of the compass. Then in the spherical triangle PZB the two sides b and ϕ, with the included angle Z, are known, and it is required to find the third side z, which is the axial angle of inclination, or the angle that a freely suspended dipping needle makes with the axis of the Earth.

The angle z is then given by

$$\sin z = \sin \phi, \sin Z, \operatorname{cosec} P$$

P having been previously found from

$$\tan \frac{P + B}{2} = \frac{\cos \frac{1}{2}(b - \phi)}{\cos \frac{1}{2}(b + \phi)} \cot \frac{Z}{2}$$

$$\text{and } \tan \frac{P - B}{2} = \frac{\sin \frac{1}{2}(b - \phi)}{\sin \frac{1}{2}(b + \phi)} \cot \frac{Z}{2}$$

In this way points for plotting the curves were obtained at every 20° of latitude and 30° of longitude up to latitude 60° north and south of the equator, taking the inclination and declination angles from the Admiralty Charts for 1907, and supplementing the points by making use of the 'No variation' line wherever it occurred along the selected parallels, and on the intermediate 10° of latitude.

Above latitudes 60° N. and S. the same charts were used for the few degrees higher in latitude that they include; but beyond this the observations of Polar expeditions, and Dr. J. Neumayer's charts in Berghaus' *Physikalischer Atlas* have been used. An attempt has been made in places to bring these latter data to the epoch of the Admiralty Charts, but so little is known of the secular change in high latitudes that the figures here can only be approximate. Still, they are not likely to be much in error, and doubtless quite accurate enough for giving a good general idea of the direction taken by the curves. Later on many more angles were computed in the equatorial regions in order to trace the 10° curves and their points of convergency.

In the computations no great accuracy was attempted, nor indeed was possible, since the data had to be scaled off the charts; but the results of the computations are more than sufficiently exact for the plotting of the curves. Five-figure logarithms were used, but no attempt was made, except in a few instances, to work to nearer than 1′. Possibly the greatest error in the computed angles would not exceed 4′, apart from errors due to the fact that the data are only scaled off the charts. After all these charts are only preliminary productions, and it would be well, if anything further is done in the matter, to compute more points, taking them, and all the others, from the actual observations instead of scaling from the charts.

No special importance has been given to the magnetic poles, or areas of 90° dip or inclination below the horizon; and they have been treated just as all the other points. The fact that the dip is 90° below the horizon in these areas is in itself probably of no great significance. Other areas have been found where the dip is 90°, one of which was only recently discovered by Dr. Bauer s party at Treadwell Point, Alaska (see Dr. Hale's article in the 'Annual Report of the Board of Regents of the Smithsonian Institution,' 1913, p. 147), so that this fact alone may mean very little. It may, however, be interesting to see what takes place as regards the new curves at these dip poles. The north magnetic pole is approximately in 70° 5′ N. lat. and 97° W. long., while the south magnetic pole is roughly situated in 72° 30′ S. lat. and 153° 45′ E. long. Taking the north magnetic pole as an example: Since there is no 'variation,' all that has to be done to obtain the axial inclination is to add the latitude 70° 5′ to the 90° inclination (horizontal) and the result is 160° 5′, which is the angle required. This case is given in Fig. 4; and it appears probable that somewhere only a few degrees from the geographical north pole (perhaps near the mean centres of the axial inclination curves) the angle would be

about 180°. The same holds good for the south polar regions; only there, since the distribution of total intensity is very unequal, being much greater on the South Victoria Land and Australia side than the South America side, the point of 180° axial inclination is likely to be further from the geographical pole.

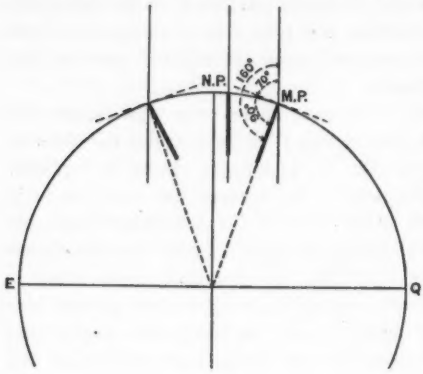


Fig. 4.

The red spots on the charts show approximately the mean centres of the new curves, and it will be noticed that both in the north and south polar regions these are about 6° to 8° from the geographical poles.

Owing to irregularities, especially in the declination, the minimum axial inclination angle computed in the equatorial regions frequently exceeds 10°. The lowest angle found is about 1°·5, and this is in lat. 10° S. and long. 58° W. Somewhere quite near here there may be a point where it reaches 0°. The only other area where it seems possible that such a low angle will be found is between Ceylon and Sumatra, where the angles are again very small.

It will be clear that since there are parts where the minimum angle exceeds 10°, the axial inclination curves of 10° are not continuous round the Earth as is the case with the others, but are closed at the ends where they converge and meet at certain points as shown on the charts. Curves showing smaller angles, such as 5°, would, for the same reason, form ovals within the 10° curves.

A very important feature which I think the charts bring out is the connection between the centres of maximum total intensity and the direction taken up by the magnetic needle as indicated by these new inclination curves. In the northern hemisphere there are two areas of maximum intensity, one in North Siberia and the other in Arctic America; the latter, where the land extends to a higher latitude, being somewhat stronger than the former. Now, it will be noticed that the new axial inclination curves are roughly elliptical near the geographical north pole, and are apparently drawn out in the direction of these two centres of maximum intensity, being drawn more towards the American centre than towards that in Siberia. Further, it will be seen that at right angles to these centres the intensity is greater on the Bering Strait side than on the opposite European side; and here again the curves are drawn out towards the area of greater intensity, although not anything like to the same extent as in the direction of the Siberian and American maximum centres.

In the southern hemisphere there appears to be only one centre of great intensity, or if there are two the second is in the neighbourhood of the first and on the same side of the geographical pole, so that the two may be considered to act as one for our purpose. This combined centre is between Tasmania and South Victoria Land; but here again it is noticeable that the curves of axial inclination are drawn in the direction of this centre. As there is no corresponding centre on the opposite side of the south geographical pole, the deflection of the curves of inclination is all in one direction, as indeed it should be; on the side opposite the centres of maximum intensity the curves appear to be drawn in towards the geographical poles, as indeed might be expected.

The centres of maximum total intensity in the northern hemisphere are both in the northern parts of the great land masses, and in the southern hemisphere the centre, single or combined, is in the neighbourhood of the greatest land masses in high southern latitudes, that is, it is in the South Victoria Land, Tasmania, and Australia section; and this seems to point to the conclusion that the distribution of land and water on the Earth's surface has a great deal to do with the distribution of the magnetic intensity, either by the indirect and consequent effect of temperature or in some other manner not yet fully explained. However, it seems likely that if the Earth's surface were altogether composed of one material, such as land of equal formation and magnetic permeability, the magnetic intensity would be arranged in more or less regular zones following the parallels of latitude and increasing from the equator to the poles.

It appears to be the distribution of magnetic intensity over the Earth's surface that affects the direction taken by the needle, and not the positions of the 90° dip poles. Further, if we consider the question of declination, the compass takes up that position in the lines of force with regard to its horizontal orientation in which it is balanced by the surrounding magnetic forces, and rarely points to the magnetic poles of 90° dip. In fact, as a rule it points to no pole at all.

It is not my intention to attempt any discussion on the theory of the complicated subject of terrestrial magnetism, and these notes have been written only as explanatory of the charts and the manner in which they have been constructed; but from what has been said I think it must be concluded that the selection of the geographical axis of the Earth as the axis of reference for the new inclination angles is the best to be found, and, as has been pointed out, it is certainly in agreement with the distribution of magnetic intensity and the maximum centres. The regularity of these new axial curves as compared with curves of dip measured from the horizon is another matter to which I would call special attention, and it seems to furnish additional proof that the line which I have chosen is not an unreasonable one to take for the reduction.

In order to show that the difference in the regularity in the curves is not due to distortion caused by the projection on which the charts have

been constructed, I have also drawn them, or as many of them as I could conveniently show, on a globe, and proved clearly that this is not the case.

The charts of the northern and southern hemispheres first drawn were both for the year 1907, but as it seemed desirable to arrive at some idea of what change is taking place in the curves, I have since completing these drawn others for a much earlier date, the year 1700. The data for these are by no means so trustworthy as for the 1907 charts, but I have taken the best I know, the tables and charts of inclination, declination and intensity given for that year in Dr. H. Fritsche's 'Atlas des Erdmagnetismus.' As the work of computing the points for the reduction of the curves is very considerable, except in the polar regions, I have not taken so many as in the case of the 1907 charts, but quite sufficient I believe to

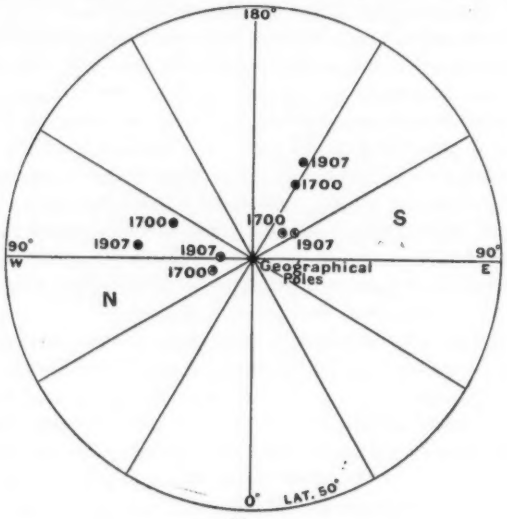


Fig. 5.

give the general form and direction of the curves. A comparison of the charts for the two dates should be interesting, and in a general way perhaps help to show what changes have taken place in the magnetic elements during the interval of 219 years.

Perhaps the most important point is the relative positions of the mean centres of the new axial curves with reference to the magnetic and geographical poles. These positions are all shown on one diagram with the geographical pole in the centre. On this diagram (Fig. 5) the positions of the magnetic dip poles and those of the mean centres of the axial curves for 1700 and 1907 are all indicated, the former by ● and the latter by ⊙. On the same diagram the south magnetic pole and the mean centres of the southern axial curves for 1700 and 1907 are also

shown in the positions where they would be seen if it were possible to view them through the Earth. This method has the advantage of exhibiting not only the positions of these points with reference to each other, but of bringing out more clearly than I could find any other way of doing the relative longitudes of the northern and southern magnetic poles and axial centres, and the fact that they are by no means 180° apart. The mean of the positions on the 1907 charts shows that the distance between the geographical poles and the centres of the curves is very nearly one-third the distance between the magnetic and geographical poles, while the mean of all four charts, although somewhat more than one-third, does not differ widely from this.

This is an important fact, and one to which Prof. A. Schuster, who saw the 1907 charts with the first part of these notes, calls attention in a letter. He says that he has assured himself "that on the supposition of a uniformly magnetized sphere the lines of equal angle between magnetic force and the direction of the Earth's axis should be closed curves approximating circles round a point between the magnetic and geographical poles, and one-third of the distance from the geographical pole. This, in fact, is the main feature of Reeves' curves, as the required fraction of distance ($\frac{1}{3}$) is very nearly satisfied."

The mean centres of the axial inclination curves have been obtained by finding graphically on the original large-scale charts the centre of the separate curves for each chart, and then obtaining their mean position. These must be considered as approximate only, but are probably not more than a degree or so in error in any case. According to these charts the mean distance of these centres from the geographical poles for the 1907 are :

Northern hemisphere	5°·5
Southern „	8°·5
	7°·0 mean.

And for the 1700 :

Northern hemisphere	7°·0
Southern „	6°·5
	6°·7 mean.

Thus it will be seen that the mean distance of these centres from the geographical poles is nearly the same for both although the interval in time elapsed is over two hundred years.

An interesting relation exists between the axial inclination curves, the geographical latitudes, and the distance of the mean centres from the geographical poles, which is that *half the mean of the axial inclination angles round any parallel of latitude minus the distance of the mean of the N. and S. mean centres of the curves from the geographical poles equals approximately the latitude.* As in many cases the data can only be rough,

and as in parts, especially in the polar regions, comparatively few points are available for the computation of the curves, it was not likely that very accurate values would be obtained, but the results are sufficiently near to show that this relationship exists. The rule may be thus briefly expressed:

$$\lambda = \frac{a}{2} - b$$

where λ = geographical latitude.

a = mean of axial inclination angles round any parallel of latitude.

b = mean distance of N. and S. centres of axial inclination curves from the geographical poles.

The distances of the mean centres of the axial curves, b, from the geographical poles were, in the first place, merely scaled off the charts, and a table worked out with these values; but by transposing the formula it is possible to obtain the distances of b from the geographical poles from the known latitudes and the computed axial inclination, since the relationship clearly exists.

The formula for this would then be

$$b = \frac{a}{2} - \lambda$$

I therefore propose to give tables using the computed values of b, which give somewhat better results than those which depend upon the chart plottings of b, although the difference between the two results shown in the first table computed and that here given for any latitude is only $0°{\cdot}7$ for the 1907 charts, and $1°{\cdot}2$ for the 1700 charts.

For the 1907 charts the mean position of b comes out by the above formula for the northern hemisphere $7°{\cdot}4$ and for the southern $8°{\cdot}0$, and the mean of these $7°{\cdot}7$. Using this value of b the results are as follows:

1907 Charts.

λ	$\frac{a}{2}$	b	*Resulting value of* λ.	*Errors.*
70° N.	75·9	7·7	68°·2	− 1·8
60° N.	67·4	7·7	59°·7	− 0·3
40° N.	49·2	7·7	41°·5	+ 1·5
20° N.	27·0	7·7	19°·3	− 0·7
0° N.	8·5	7·7	0°·8	+ 0·8
20° S.	30·0	7·7	22°·3	+ 2·3
40° S.	48·7	7·7	41°·0	+ 1·0
60° S.	66·3	7·7	58°·6	− 1·4
70° S.	76·3	7·7	68°·6	− 1·4
			Mean error ...	0·0

Dealing now in the same manner with the 1700 charts we find that the mean value of b for the northern hemisphere is $8°{\cdot}5$, and for the southern hemisphere $7°{\cdot}3$, the mean of which is $7°{\cdot}9$. So using this value of b the following results are obtained:

1700 Charts.

λ	$\frac{a}{2}$	b	*Resulting value of* λ.	*Errors.*
70° N.	76·8	7·9	68°·9	− 1°·1
60° N.	68·6	7·9	60°·7	+ 0°·7
40° N.	50·9	7·9	43°·0	+ 3°·0
20° N.	28·5	7·9	20°·6	+ 0°·6
0° N.	7·5	7·9	0°·4	− 0°·4
20° S.	28·4	7·9	20°·5	+ 0°·5
40° S.	49·1	7·9	41°·2	+ 1°·2
60° S.	66·9	7·9	59°·0	− 1°·0
70° S.	74·3	7·9	66°·4	− 3°·6
		Mean error		− 0°·05

The results of these tables are, I venture to think, of some interest. So far as I know they have not been brought out before. If we could assume a sphere so magnetized that for every degree by which the latitude increased there was an increase of one degree in the horizontal dip taken in the true meridian, then it will be clear that while the horizontal dip is changing from 0° at the equator to 90° at the poles, the axial inclinations would increase from 0° to 180°, and since the axial inclination angles, if we disregard declination, are the horizontal dip angles with the

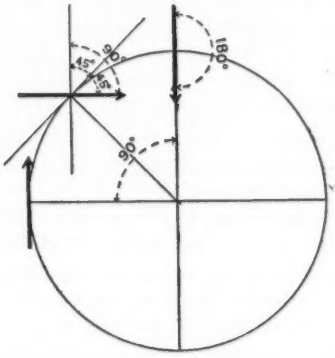
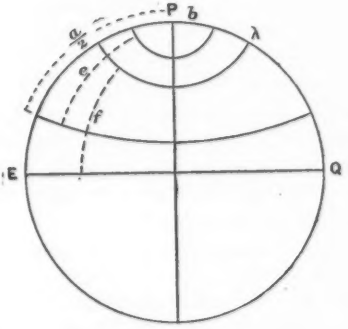


Fig. 6.



$\frac{a}{2} - b = e = f$ *(approx.)*

Fig. 7.

latitude added, in this case half the axial inclination angle would equal the latitude of the place (see Fig. 6). But the earth is clearly not so magnetized, and there are many irregularities in its magnetization; yet from the facts brought out in these charts and tables it appears that the combined result of its magnetization is that the *mean* of half the axial inclination angles taken round any parallel of latitude, minus the distance of the mean centre of all the curves from the geographical poles (shown by a small circle *b* on Fig. 7) is very nearly equal to this latitude

Note written after the Meeting.

I have read Dr. Chapman's notes which follow this paper with considerable interest, and thank him for the trouble he has taken in the matter. Apart from any special consideration his remarks are of importance, as they set forth concisely the application to the subject of the theory that the Earth is uniformly magnetized along a diameter roughly agreeing with that of a line joining the magnetic poles. But there are different opinions amongst authorities as to the normal direction of the Earth's axis of magnetization, and various lines have been suggested by those who are well qualified to deal with the subject, although, perhaps, all have arrived at the conclusion that whatever the primary cause and direction of the magnetizing agency the resulting magnetic axis is inclined at an angle to the geographical axis.

If, in the reduction of my curves, I had selected a line joining the magnetic dip poles, apart from the fact that these are not constant for all times, and so the curves resulting would not be suitable for comparing results of different dates, these poles are not 180° of longitude distant from one another, and consequently the line would not pass through the centre of the Earth; and so I finally came to the conclusion that the only suitable line for the reduction of the curves was that of the geographical axis. Another reason that leads me to conclude that my selection is the most satisfactory one is that the axial inclination curves are, as previously pointed out, perfectly consistent with the distribution of magnetic total intensity, and are deflected just where they might be expected to be, which would not be the case if they had been reduced to an axis joining the magnetic dip poles, or indeed any other axis inclined more than a very few degrees to the geographical axis.

W. Sutherland in 'Terrestrial Magnetism' (vol. 5, p. 73) states that if the Earth carries round an electrostatic field in its rotation (of which there seems good evidence), "then it will have the axis of its magnetic field identical with the axis of rotation, which is the chief approximate fact of the Earth's magnetism. The actual obliquity of the magnetic to the rotational axis is traced to the unsymmetrical magnetic permeability of the Earth." I am inclined to believe that my curves tend to support this theory of the Earth's magnetism.

Taking all things into consideration, I venture to suggest that it is not inconsistent to suppose that the normal direction in which the Earth is magnetized (by east and west electric currents, or some other means) is that of its geographical or rotational axis, although, owing to the unequal magnetic permeability of the material forming its crust the *resulting* magnetic axis, and the lines of force, become oblique and are not in line with the geographical axis.

However, as previously stated, it is not my intention to discuss the theory of Terrestrial Magnetism, and I leave this to others better qualified

to deal with it. All I desire to do is to call attention to the facts brought out by these charts, and I venture to hope that the considerable amount of time and labour I have expended in preparing them may not be altogether in vain.

Before the paper the CHAIRMAN (Dr. H. R. MILL) said: We have met this afternoon to hear a paper on "A Transformation of the Dip Chart" by our friend Mr. Reeves. It is a subject which has been occupying his attention, as I know, for more than a quarter of a century, and on which we used to have many discussions in the old Savile Row days, when we were colleagues in the Society. Every one will hear this paper with the more interest since it has been worked out by the Society's Map Curator in his spare time.

(*Mr. Reeves then read the paper printed above, and a discussion followed.*)

Mr. HINKS: When this paper came into my hands I took an opportunity of referring it to Prof. Schuster, one of the greatest authorities on magnetism in this country, and he kindly sent me the following notes, part of which Mr. Reeves has already quoted to you. Prof. Schuster writes: 'The Earth may, roughly speaking, be considered to be a uniformly magnetized sphere, with the axis of rotation inclined to the axis of magnetization. When I first heard from you about Mr. Reeves' result I thought it just possible that it might indicate that the outstanding part (*i.e.* that which cannot be referred to a uniformly magnetized sphere) might be related more nearly to the axis of rotation than to the axis of magnetization. In that case the results of the paper would be of considerable importance; but on looking at the curves I am very doubtful about this point. The dip is rather an awkward element to work with, and it cannot easily be represented in terms of spherical harmonics; but I have assured myself that on the supposition of a uniformly magnetized sphere the lines of equal angle between magnetic force and the direction of the Earth's axis should be closed curves approximating to circles round a point between the magnetic and geographical poles, and one-third of the distance from the geographical pole. This, in fact, is the main feature of Reeves' curves, and the required fraction of distance (1/3) is very nearly satisfied."

Dr. S. Chapman then contributed to the discussion the contribution which is printed as a separate paper, p. 166.

Dr. C. CHREE, F.R.S. (Superintendent, Kew Observatory): I have not had the privilege of seeing the paper, but I may say after hearing it read that I have come to the same conclusion as Prof. Schuster. I am not sure that Dr. Chapman made the position quite clear. The question with regard to the uniform magnetism of the Earth may seem rather an arbitrary assumption. But it is not an assumption; it is a fact. If we take the observational data embodied in charts and treat them mathematically we find that apart from all assumptions the first approximation does give a uniformly magnetized sphere. And we know that the axis about which that uniform magnetic distribution occurs is not the geographical axis, nor the axis approaching most closely to what we know as the magnetic poles, but is inclined 11° or 12° to the geographical axis. So that we know that the first approximation should give us curves centred on an axis, but I should hardly have expected to get actual curves as regular in shape as Mr. Reeves has obtained. I think his doing so is useful, because he has reached his results without any prejudice. I can

also, I hope, appreciate the enormous amount of time he must have given to this laborious work. I was also interested to see that Mr. Reeves referred to some of the late Prof. Fritsche's results. In his lifetime he did a great deal of mathematical work which showed remarkable industry and considerable imagination.

Mr. HINKS: I have been much impressed by the apparent ease with which Dr. Chapman has, in the course of a rather brief week-end, put together a most interesting explanation of the result that Mr. Reeves has put before us. At first sight it is very striking that Mr. Reeves has been able to make those elongated curves of equal dip so very much more circular, and to find that Dr. Chapman is able to give us a simple convincing explanation of that fact is of great interest. As a man very ignorant of magnetism, I should like to ask if, when Dr. Chree says that the Earth to a very close degree of approximation is uniformly magnetized about a certain axis, his axis is a diameter of the spheroid?

Dr. CHREE: Yes.

Mr. HINKS: In spite of the fact that the line joining the magnetic poles is so far from being a diameter that it passes something like 1000 miles from the centre of the Earth?

Dr. CHREE: Something like that. The position of the south pole is not very accurately known, as a matter of fact.

Mr. HINKS: I think Prof. David fixed it within a few miles.

Dr. CHREE: And other people have found it otherwise.

Mr. HINKS: Yes, but I think Prof. David has some claim to be considered as the authority. He is the only man who has made observations near it.

Dr. CHAPMAN: There does not seem much difficulty in defining the position of the magnetic poles. I think that the distance in question is 700 miles.

Mr. HINKS: In any case the line joining the magnetic poles runs at least 700 miles from the Earth's centre, so that it seems we are in the presence of another extraordinary fact: that although the magnetic poles are so unsymmetrical upon the Earth, you can by assuming uniform magnetism about a line which does not pass very nearly through either of them, arrive at results which are to a considerable degree of approximation the results observed.

Dr. CHAPMAN: Your mathematical representation requires the magnetic axis to pass through the centre of the Earth, and by that means you can get an approximation to the observed fact.

Mr. HINKS: When you call it a first approximation, how satisfactory an approximation is it? For instance, within what percentage does it give the intensity?

Dr. CHREE: I think somewhere about 85 per cent. The data on which the mathematical solution is based are really from latitudes between 60° N. and 60° S., though the mathematical conclusions are not restricted to that area. You simply assume that there is a distribution possible in spherical harmonics, and then you determine the constants of that distribution from the data of your charts; and what you find is that the coefficients of the first-order terms are very much the biggest. But different people dealing with data from different sources differ considerably as to the results for the higher-order terms.

Dr. J. W. EVANS: I should like to ask Dr. Chapman and Dr. Chree how far this axis, which is the basis of the first approximation to the uniformly magnetized Earth, how far that agrees with the Earth's poles? Is that also approximately one-third the distance from the pole of rotation?

Dr. CHREE: It is about 12° away from the axis of rotation, and in much the same azimuth.

Dr. EVANS: I was very interested in Mr. Reeves' work, which is a great advance, at any rate, on the popular understanding and appreciation of the distribution and direction of the dip over the whole Earth. It seems to me an extraordinary fact, and quite contrary to what one would expect, that the maximum magnetization should be in the direction of the great continental masses; for if there is one thing we thought we were assured of, it was that the great continental masses represent the regions where there is the greatest thickness of non-ferruginous material, where the earth is mainly composed of sedimentary and of granite rocks, in which there is the least material to affect magnetism. There is evidently a fallacy somewhere.

Dr. CHAPMAN: I was looking up two papers in the French Academy. Mr. Wilde has found that the distribution of magnetism over the Earth's surface can be represented if you have a uniformly magnetized sphere and over it lay slips of sheet-iron covering the ocean. He finds that that reproduces the positions of the two magnetic with reference to the geographical poles, and that was confirmed by Mons. Idrac about four years ago. And M. Recluse last year tried to explain that by showing that beneath the oceans there is a layer of iron cooler than that under the land; that is to say, that this layer of iron is below the temperature at which magnetization became impossible, so that there may be a layer of iron under the ocean which is sufficiently cool at a depth where the iron layer is in order to magnetize and correspond with these strips of sheet-iron which they used.

The CHAIRMAN: I should like to thank Mr. Reeves for bringing this matter before us, and also Dr. Chapman and Dr. Chree for the lucidity with which they have brought the light of theory to bear upon the results of observation. It is gratifying to find that the result of a piece of patient investigation of actual facts, without the guidance of any theory whatsoever, should produce such a charmingly symmetrical result; and that this symmetrical result should be so perfectly explained by a theory that does not require to be strained in order to fit it. It makes one wonder why these lines have not been suggested by theory before Mr. Reeves had with pain and labour dug them out and displayed them on a globe in this manner.

Mr. REEVES: I am very much obliged to Dr. Chapman, Dr. Chree, and Dr. Mill for their remarks. There is no theory about what I have done; it is simply practical application of observations, plotted in a new way. When you do that you get much more regular and, to my mind, more reasonable curves than if you take the ordinary dip measured from the horizon. The work I have been doing is more or less connected with some experimental work of my own which is interesting me considerably, and perhaps some day I may have the honour of showing it here.

ON METHODS OF REPRESENTING THE DISTRIBUTION OF MAGNETIC FORCE OVER THE EARTH'S SURFACE

S. Chapman, M.A., D.Sc., Fellow of Trinity College, Cambridge, and Chief Assistant at the Royal Observatory, Greenwich

§ 1. THE magnetic force at any point of the Earth's surface requires, like any other force, three elements for its specification. These elements may be the components of the force along any three non-coplanar directions, or the magnitude of the force together with two directions. It is customary, and convenient, to indicate the distribution of the values of any such element by a set of isomagnetic lines, having the property that each line passes through all the points on the sphere at which the element has a given value associated with the line. There are, for instance, the isomagnetic curves of declination, dip, and total or horizontal intensity.

§ 2. Two classes of isomagnetic curves may be distinguished, according as to whether the determination of the corresponding element does or does not require a reference to some special direction or diameter (axis) of the sphere. The first class, which may be termed *intrinsic* isomagnetics, includes the curves of equal total, vertical, or horizontal intensity, and of dip; these involve reference either to no direction at all, or else only to the radial direction associated with the point where the element is measured. It is not possible, however, to give a complete specification of the distribution of force by intrinsic isomagnetics, since there is no natural datum from which to measure the direction of the horizontal component of the force. This direction is usually indicated by means of the curves of equal declination or "variation," so important in the practice of navigation. These curves, however, are relative isomagnetics, as are also the curves of equal axial inclination drawn by Mr. Reeves, since the directions, in the one case of declination, in the other of axial inclination, are measured relatively to a special diameter, and to the meridian curves defined by it. The choice of the axis of rotation for this axis of reference is dictated only by considerations of practical or theoretical advantage, and corresponding sets of curves might be drawn with respect to any other axis of reference.

§ 3. One other important intrinsic set of magnetic curves may be noticed, although they are not strictly isomagnetic curves. These are the lines of horizontal (tangential) force, which have the property that the direction of the line passing through any point is the direction of the horizontal component of force at the point. These lines are, of course, entirely different from the lines of equal declination. They have two foci, one at each magnetic pole. These are also foci for the lines of equal declination, but the latter have two additional foci at the geographical poles. It seems likely to

be a general feature of relative isomagnetics that they are in some ways more complicated than the corresponding intrinsic curves. We may also note that a complete intrinsic specification of the distribution of magnetic force over the surface of the Earth is afforded by the lines of force in conjunction with any two of the intrinsic isomagnetics already mentioned (§ 2). If, on the other hand, an axis of reference is chosen in order to afford a datum for the measurement of declination, the most natural trio of isomagnetic curves to adopt for a complete magnetic specification is undoubtedly that comprising the curves of equal total intensity (intrinsic), and the curves of equal declination and of equal axial inclination. Mr. Reeves' work for the first time affords us a representation of these latter.

§ 4. A noteworthy feature of Mr. Reeves' curves is that they are of a simpler and more regular character than are the curves of equal dip.* This constitutes a claim to careful study, in order that the interpretation of the fact may be made clear. Mr. Reeves concludes that it indicates the special suitability of the geographical axis as axis of reference, and as the axis, probably, of the normal or primary magnetizing agency. The geographical axis has, indeed, a strong claim to be the most suitable axis to take, especially since the corresponding isoaxiclinals form the natural complement to the lines of equal declination (§ 3). But theoretical considerations indicate that the uniformity and regularity of Mr. Reeves' curves are, in the main, not due to any special physical significance of the geographical axis, and that the same features would probably appear if any other axis had been chosen, provided that its poles, like the geographical poles, were not very distant from the magnetic poles. Moreover, as Prof. Schuster has remarked, the situation of the centre of Mr. Reeves' curves (about one-third of the distance from the geographical to the magnetic poles) is in excellent agreement with what theory suggests, on the supposition that the Earth is approximately uniformly magnetized along a direction roughly agreeing with that of the line joining the two magnetic poles. Thus Mr. Reeves' curves must be regarded rather as affording a novel and interesting confirmation of the usual view of an approximately uniform, oblique magnetization of the Earth, than as indicating the geographical axis as, magnetically, the normal or fundamental axis.

§ 5. In order to elucidate these points, I have followed Prof. Schuster in considering the isoaxiclinals for a uniformly magnetized sphere, corresponding to various axes of reference. Imagine a sphere, with centre O, uniformly magnetized along the direction of the magnetic axis MOM', M

* This would appear to be true except near the equator. As will be seen later, however, theoretical considerations (§ 7) suggest that the isoaxiclinals—as, for brevity, the lines of equal axial inclination may be termed—should break up into two families of curves near the equator, with a curve intersecting itself twice as the transition stage. This feature did not appear on Mr. Reeves' charts as exhibited on February 18, but I think it probable that on careful examination the data will be found to indicate this feature.

and M′ being the magnetic poles. By symmetry, all the intrinsic isomagnetics are circles of latitude, and the lines of horizontal force are meridians. The relative isomagnetics, when referred to the magnetic axis, are also circles of latitude (the isogonic lines, in fact, in this case become an isogonic surface, for the horizontal magnetic force is *everywhere* directed along the meridians); the axial inclination is the simple sum of the dip and the latitude. Our object is to determine the isoaxiclinals when any other axis of reference, ROR′, is chosen, having its poles R, R′ distant respectively from M, M′ by an angle α.

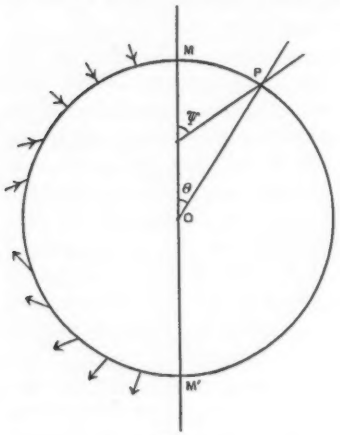


Fig. 1.

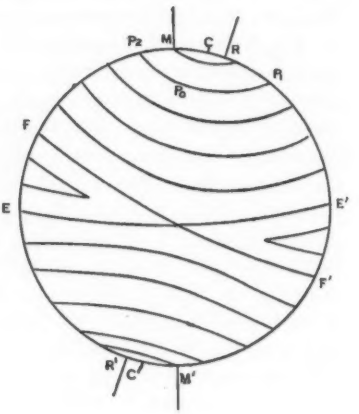


Fig. 2.

By the theory of a uniformly magnetized sphere (to be found in any mathematical treatise on magnetism) the magnetic force at any point P on the sphere lies in the plane POM, and its direction makes an angle ψ with the magnetic axis, where

$$\tan \psi = \frac{3 \sin 2\theta}{1 + 3 \cos 2\theta} \qquad (1)$$

θ being the angular distance of P from the magnetic pole M. In the left hand of Fig. 1 the directions of the tangents to the magnetic force in different magnetic latitudes are indicated. As is clear from the formula, ψ increases from 0° to 180° as θ increases from 0° to 90° (*i.e.* as P moves from the pole to the magnetic equator). Its mean rate of change is hence twice that of θ, as also twice that of dip, which decreases from 90 to 0°. When θ is small, ψ is approximately equal to $\frac{3}{2}\theta$,* so that ψ at first changes at $\frac{3}{2}$ times the rate of θ, and three times as quickly as the complement of

* Thus, writing ψ for tan ψ, 2θ for sin 2θ, and 1 for cos 2θ, when θ is small we have the following approximate relation in place of (1):

$$\psi = \frac{3 \cdot 2\theta}{1 + 3} = \tfrac{3}{2}\theta$$

the dip, $\psi - \theta$ (and therefore also three times as quickly as the dip itself). These facts are of importance in the later discussion (§ 8). The following table gives a number of corresponding values of ψ and θ, and shows how remarkably good is the approximate relation $\psi = \frac{3}{2}\theta$, from $\theta = 0°$ to $\theta = 30°$ at least. The value of ψ corresponding to $\theta = 0°$ is, of course, 0°.

θ	5°	10°	15°	20°	25°	30°	35°	40°	45°
ψ	7·5	15·1	22·6	30·3	38·1	46·1	54·3	62·8	71·6
θ	50°	55°	60°	65°	70°	75°	80°	85°	90°
ψ	80·8	89·5	100·9	112·0	124·0	136·8	150·6	165·1	180·0

§ 6. Let us now consider the form of the isoaxiclinals relative to the given axis ROR′, inclined at the angle α to the magnetic axis. In the first place, it is clear that the curves will be symmetrical on the two sides of the plane MOR. Again, when R coincides with M, the curves, as we have already remarked, are circles. As R is moved away from M, they may be expected to suffer distortion, but in a regular manner, so that for small values of α they are likely to be smooth ovals; it will be convenient to gauge their general form by first determining where they cut the plane MOR and the perpendicular plane through the magnetic axis. We will consider the isoaxiclinal which passes through all points at which the force is inclined to ROR′ at an angle χ. Let P_1, P_2 be the points where this curve cuts the axial plane MOR, the point P_1 being the one further from M; let θ_1, θ_2, ψ_1, ψ_2 denote the corresponding values of θ and ψ. Clearly

$$\chi = \psi_1 - \alpha = \alpha - \psi_2. \tag{2}$$

If, now, ψ_1 $(= \alpha + \chi)$ is not too great, we may replace ψ in these equations by $\frac{3}{2}\theta$, and so determine the position of the points P_1, P_2. Thus

$$\psi_1 = \tfrac{3}{2}\theta_1 = \alpha + \psi, \qquad \psi_2 = \tfrac{3}{2}\theta_2 = \alpha - \chi. \tag{3}$$

Let C be the point midway between P_1 and P_2, *i.e.* the centre of the isoaxiclinal in the plane MOR. We have, if θ_0 is the distance of C from M,

$$\theta_0 = \tfrac{1}{2}(\theta_1 + \theta_2) = \tfrac{1}{2} \cdot \tfrac{2}{3}(\alpha + \chi + \alpha - \chi) = \tfrac{2}{3}\alpha. \tag{4}$$

Thus the position of C is independent of χ, so that all the isoaxiclinals

Again, if we write $\psi = 180 - \psi'$, $\theta = 90 - \theta'$, (1) becomes

$$\tan \psi' = \frac{3 \sin 2\theta'}{3 \cos 2\theta' - 1}$$

and near the magnetic equator, where θ' and ψ' are small, this is approximately equivalent to

$$\psi' = 3\theta'$$

Thus, at the equator, ψ (or ψ') changes thrice as quickly as θ, and twice as quickly as the dip: cf. § 7.

have the same "centre" C, which is situated one-third of the way from the pole of reference R to the magnetic pole M.

We have not shown, so far, that other points on the isoaxiclinal are at approximately the same distance from C as are P_1 and P_2. Unless this can be done, C is hardly to be termed the "centre" of the isoaxiclinal. The demonstration, however, is quite simple. Let P′ be the point where the curve cuts the plane through MM′ perpendicular to MOR; let θ', ψ' be the corresponding values of θ and ψ. The direction of the force is, of course, in the plane MOP′, but by elementary spherical trigonometry it is clear that the condition requisite for the force at P′ to be inclined at the angle χ to OR is

$$\cos \chi = \cos \alpha \cos \psi'. \tag{5}$$

This, in view of the relation between ψ' and θ' determines θ', and therefore the position of P′. What we desire to know is the angular distance of P′ from C, which we may write ρ'. Again using the spherical trigonometry of a right-angled triangle, we have

$$\cos \rho' = \cos \tfrac{2}{3}\alpha \cos \theta'. \tag{6}$$

At this stage it is best to consider a numerical example. Suppose $\alpha = 15^\circ$ (approximately the angle between the geographical and magnetic axes of the Earth), and let us examine the isoaxiclinal for which $\chi = 30^\circ$. The centre C will be 10° from M, 5° from R; by (2), $\psi' = 45^\circ$ and $\psi_2 = 15^\circ$, whence, using the table of values of ψ, we deduce that $\theta_1 = 29$, $\theta_2 = -10^\circ$. Hence the radii P_1, P_2 of the isoaxiclinal, measured from C_1 to P_1 and P_2, are 19°·3 and 20°·0 respectively. In the perpendicular plane P′OM we have

$$\cos \psi' = \cos 30^\circ \div \cos 15^\circ = 0{\cdot}897, \text{ so that } \psi' = 26^\circ{\cdot}3$$

Hence, from the table again, $\theta' = 17^\circ{\cdot}4$, whence by (6) we deduce that $\rho' = 20^\circ{\cdot}0$. Thus the isoaxiclinal is very nearly circular, with a radius on the sphere of approximately 20°, and a centre practically coincident with C. More exactly, however, its centre is slightly nearer to the magnetic pole than is C (by about 0°·3 only), and it is very slightly broader in the direction perpendicular to the plane MOR than it is *in* that plane (40° as against 39°·3).

§ 7. Thus, as we incline the axis of reference away from the magnetic axis, the isoaxiclinals, at any rate for a considerable region round the poles, remain remarkably nearly circular, their centres being displaced at $\frac{2}{3}$ the rate of R. If, however, we examine the equatorial region we shall find rather a different situation. In the first place, since the force all round the magnetic equator is parallel with the magnetic axis, its inclination to the axis of reference (whether the angle ROM be small or large) is constant; the magnetic equator, therefore, is always an isoaxiclinal, in the case of a uniformly magnetized sphere. The corresponding value

of χ is clearly $180° - \alpha$. It is not difficult to see, however, that between M and E (E being the point where the equator cuts the plane MOR) there must be some other point F where χ again assumes the value $180° - \alpha$. With the aid of the footnote to § 5, it may also be inferred that the angle EF is approximately $\frac{4}{3}\alpha$. There is, of course, an opposite point F′ also on the same isoaxiclinal, which, in fact, consists of two branches intersecting the plane normal to MOR, as in the figure. The corresponding value of χ is $180° - \alpha$ or $180° + \alpha$ indifferently. It may now be seen, further, that the nearly circular isoaxiclinals round C gradually approach the curve FE′F, broadening out, as already remarked, in the direction perpendicular to the plane MOR; between the two branches of the equatorial isoaxiclinal there are further sets of closed curves surrounding the two points corresponding to $\chi = 180°$.

It may be remarked also that the centre of the isoaxiclinals, which for small values of χ is at C, gradually moves, as χ increases, to a position about halfway between C and M, *i.e.* one-third the way from M to R, instead of *vice versâ*, as for C. Again, as the angle α is increased, until R moves down to E′, the point F rises to M.

These considerations suffice to enable a general delineation of the isoaxiclinal curves to be made for a uniformly magnetized sphere, relative to any axis of reference. It may be added that the general equation of the curves is easily calculable, and is found to be of the fourth order; but it is too complicated to be of much service in drawing the curves.

§ 8. From the above discussion it will be clear that Mr. Reeves' curves are (except near the equator (see footnote to § 4)) in excellent agreement with what theory would predict, on the hypothesis that the Earth is approximately uniformly magnetized along a direction roughly agreeing with that of the line joining the two magnetic poles. It is to be expected, moreover, that a similar set of curves would have been obtained if any other axis of reference, not too far from the direction mentioned, had been chosen; the centre of the curves would in each case be approximately one-third of the way from the pole of reference to the adjacent magnetic pole. This is a remarkable and apparently hitherto unsuspected geometrical property of these curves.

The most striking property of Mr. Reeves' curves, however, is their regularity, in that they are so much more free from distortion than are the curves of equal dip. If the Earth were absolutely uniformly magnetized, the latter should be true circles, and the former only approximately so, whereas the position is, in fact, nearly reversed. I think it is not difficult, nevertheless, to explain this fact. We may regard the observed distribution of magnetic force as due to a uniform magnetization modified by local disturbing forces. The Siberian region of high vertical magnetic intensity is a conspicuous example of a local disturbing field. The effect of the latter is to deflect the direction of magnetic force through a certain angle (and, though with this we are not here concerned, to modify the intensity). Now, in

general, the dip $(90 - \psi \dashv \theta)$ and the axial inclination (χ) will be approximately equally affected by this deviation; this, however, is far from producing a like distortion of the isomagnetics in the two cases. As we have noticed in § 5, in the neighbourhood of the magnetic pole (say, within 30° of this or of the geographical pole) the change of ψ, or of χ the axial inclination, for a given change of θ, is thrice the corresponding change in dip. Consequently the shift in the curves of equal dip, for a given local disturbance of the normal magnetic field, will be three times the shift of the isoaxiclinals. The latter, of course, if drawn (say) for every 10° of axial inclination (which ranges from 0° to 180°) are twice as numerous as those of dip, which has only half the range. They are therefore, on the average, twice as close together, and, near the poles, three times as closely spaced. This circumstance, I think, will be found to explain the smaller degree of distortion from the circular form, in the isoaxiclinals as compared with the curves of equal dip.

I do not enter upon any question as to the cause of the local disturbances in the Earth's field, my purpose being merely to show that, with the observed features of irregularity, the curves drawn by Mr. Reeves would, on theoretical grounds, be expected to be more regular than the dip curves. The fact that the geographical axis happens to lie roughly between the magnetic pole and the Siberian focus of high intensity may, however, contribute something towards rendering the isoaxiclinals referred to that axis rather more regular and symmetrical than those drawn about other axes equally inclined to the magnetic axis.

THE PHYSIOGRAPHIC CONTROL OF AUSTRALIAN EXPLORATION

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Read at the Afternoon Meeting of the Society, 16 *December* 1918.

DURING the last twenty years our knowledge of the physiography of Australia has naturally grown enormously. New data in the realms of meteorology—especially in climatology—make it possible to estimate the value of the physical controls determining the environment in the many regions which go to build up the continent. I have thought that it would be of interest to survey briefly the history of exploration in Australia; and show approximately how Nature has here thwarted and there assisted the spread of human occupation.*

* This article has grown out of a short section I have written for a book on 'Social Problems in Australia.' This is edited by Prof. Meredith Atkinson and will probably appear in 1919.

The first exploration naturally occurred in the north and north-west. But here Australia exhibits her least attractive features. Just as the Sahara blocked progress to the south of the Mediterranean, so our similar Trade-Wind region no doubt hindered the occupation of Australia by the Dutch—which was the nearest European Power. Australia indeed seems to have inhospitably turned her back on the older centres of civilization, as if to preserve herself from invasion by the yellow or black races. She looks and will continue to look toward the Antarctic rather than to Java and India. In spite of all inducements the bulk of the population will always remain in the south-east corner, where the continent is bathed in the rains largely due to the cool Antarctic cyclones.

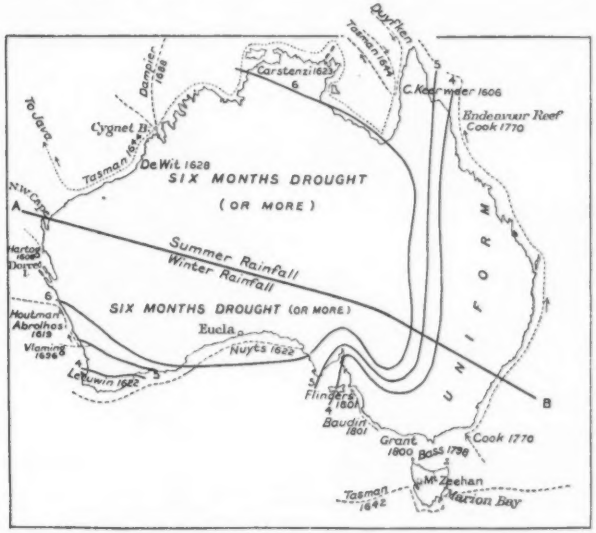

Fig. 1.—Exploration related to the winter-drought region.

Perhaps the least-known portion of the Australian coast-line is along Cape York Peninsula in the vicinity of Cape Keerweer (see Fig. 8). Apart from one or two mission stations there is no settlement to this day, and the charts still show by broken lines the nebulous state of our knowledge. Here, early in 1606, the first authentic survey of our coasts was made by Captain Jansz of the *Duyfken*, and there was nothing in the look of the place—the mangrove swamps, tea-tree thickets, and scattered eucalyptus—to tempt the Dutch or any other nations to settle there. They had, in fact, struck one of the least attractive coasts of all the "winter-drought regions," of which more anon.

The next great voyager was Hartogs, who was even more unfortunate. He discovered the only portion of the coast which receives a bare 10-inch

rainfall. The name Dorré (*i.e.* barren) Island indicates the effect of the dry off-shore trade winds which desiccate this coast for the greater part of the year. A little later, in 1619, Houtman named the coral reef off Geraldton *Abrolhos* ("Keep your eyes skinned"), and here Pelsart's ship was lost in 1629. In 1623 Carstens in the *Arnhem* surveyed the coast of Arnhem Land, which can be described as a region "of shallow waters, barren coasts, islands altogether thinly populated by divers cruel, poor, and brutal natives, and of very little use." Here, however, high humidity and a sterile soil seem to be the chief disabilities, for the rainfall is heavy during the summer. No settlement has ever taken place, and the aborigines are reported to be almost as treacherous as when they murdered Carstensz and eight of his crew.

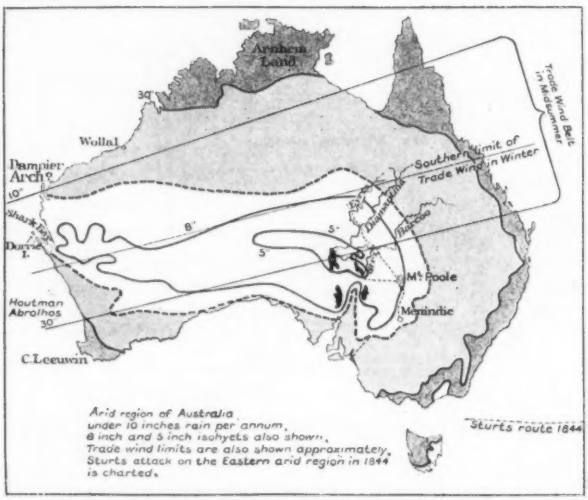
Arnhem Land
Wollal
Dampier Arch.
Shark Bay
Dorre I.
Houtman Abrolhos
C. Leeuwin
Southern limit of Trade Winds in Winter
Trade Wind Belt in Midsummer
Murchison
Gascoyne
Mt. Poole
Murrindie
Sturts route 1844
Arid region of Australia under 10 inches rain per annum. 8 inch and 5 inch isohyets also shown. Trade wind limits are also shown approximately. Sturts attack on the Eastern arid region in 1844 is charted.

Fig. 2.

In 1622 the *Leeuwin* surveyed the coast near the famous cape of the same name. In 1627 Thyssen, in the *Gulde Zeepaerd*, explored from Cape Leeuwin right along the south coast for 1000 miles. He must have been favourably impressed with the thick forests of karri-gum in the extreme west—but by a fatality he turned back at Nuyts Archipelago just as the fertile south-east coasts were reached. He had coasted around the great Australian Bight, whose shores consist of abrupt cliffs—probably due to step-faulting—from 200 to 400 feet high. At Eucla is the only anchorage for nearly 400 miles.

The first circumnavigator was Tasman, who in 1642 sailed from Java to Mauritius; then he pushed southward until he was caught by the Brave West Winds, which carried him direct to Tasmania. He first sighted

Mount Zeehan (later famed for its silver-lead), and landed in the south-east at Marian Bay north of Tasman's Peninsula. He was perhaps the first explorer who was justified in thinking that Australia was other than a region of barren wastes or stunted vegetation, defended by shallow reef-strewn waters or cliff-bound coasts. Thereafter, however, he left our shores, passing eastward, then north by New Guinea to Java; and though he returned next year (1644), it was to the same northern coasts already unfavourably known to the Dutch (see Fig. 1).

Perhaps Dampier's voyages are responsible for the lack of British interest in the new southern continent. He spent three months at Cygnet

Fig. 3.—Swanland, the most isolated agricultural region. Vegetation zones and Rainfall.

Bay near the site of Derby (West Australia) in 1688. In August 1699, having been sent by William III., he explored northward from North-West Cape. It was his misfortune to arrive at the end of winter, which is always dry, and he could find no water. "His comments on the barren appearance of the land and on the inhabitants—the miserablest people in the world—militated strongly against further investigations being made" (Favenc). In this region, moreover, the "sand and spinifex" facies of the interior actually reaches the coast. At Wollal the marsupial mole (*Notoryctes*) has recently been taken. It is a typical member of the desert fauna, and previously was only known from the centre of the continent.

The more fertile portion of West Australia was partly explored by Vlaming in 1696, who first collected the black swans (near Perth) and named the Swan River. The old name of the "Swan River Colony" for this well-defined region in the south-west has recently been revived in the name "Swanland." The reasons for its isolation are purely meteorological, and will become apparent later when inland exploration is being dealt with.

Cook, in 1770, was the first voyager to reach those portions of the continent, which—like all eastern coasts near the tropics—are beneficially affected by the constant Trade Winds or by the rain-bearing systems known as the east-coast cyclones. It is noteworthy that his was a truly

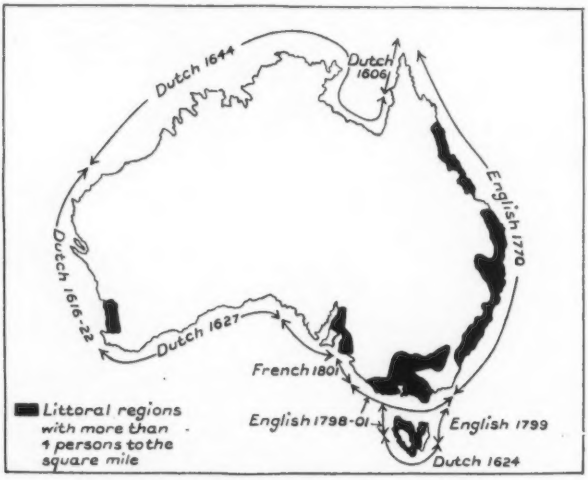

Fig. 4.—Relation of exploration to present close settlement.

scientific expedition—and England has here reaped a rich reward from this but too rare example of her encouragement of science. For it was the authoritative reports of Banks and others which contributed largely to the founding of the first settlement in Australia. Cook reached Cape Everard in Victoria in 1770 (see Fig. 1) and charted the whole east coast northward to Torres Straits. The first fleet arrived at Botany Bay in 1778, and local exploring expeditions led by Bass, Flinders, and others had filled in the gaps in the south-east by the end of 1801.

We may pause here to see how present settlement is related to the early discoveries of the coast of Australia. It is interesting to note that some sixty-four of the eighty largest towns in Australia (*i.e.* those with more than three thousand inhabitants) lie in regions whose coasts were discovered by the English. Of all the littoral explored by the Dutch—

from Cape York to the east of the Australian Bight—only the small region of Swanland is suited to close settlement by people of our race.

The noble harbour of Port Jackson determined the site of the first settlement in 1788. This unique sheet of water owes its deep frontages to the fact that it is a drowned river valley, depressed by the same forces which formed the famous Blue Mountain scarp to the west. The folding accompanying the formation of the latter feature determined the course of the Nepean River to the west. This cut off the stream which drained into Port Jackson, and so prevented the channel from being silted and obliterated. *Per contra*, but little alluvial is preserved along the harbour shores, and so we find the early settlers having recourse to the valley of the capturing river for their cattle pastures near Camden, and later for their crops at Richmond.

A simple grand fold has buckled the Hawkesbury sandstones so that they are 3000 feet higher at Katoomba than at Sydney. Growth during the first thirty years of the young colony's life was thwarted by this unusual type of mountain barrier. Here are the finest "bottle-neck valleys in the world, and their evolution remained a puzzle until David's research eighty years later.

Darwin himself was astonished by them in 1835, and suggested marine erosion as their origin. He wrote, ". . . Great arm-like bays, expanding at their upper ends, penetrate the sandstone platform. . . . To descend into some of these valleys it is necessary to go round 20 miles. . . . But the most remarkable feature in their structure is that, although several miles wide at their heads, they generally contract towards their mouths to such a degree as to become impassable. . . ."

The hard sandstones actually cap much softer shales. The rivers and rains are rapidly undercutting the soft shales in the *broad upper valleys*. But where the rivers flow *through the monocline-fold* itself (as near Mulgoa and Penrith) the hard layer is *on edge*, as it were, and the river can here only cut a narrow notch in the resistant strata.

All attempts to penetrate the monocline rampart by the natural routes —the valleys—failed. Barallier in 1802 penetrated to the south-west—*viâ* Mittagong and across the Wollondilly—until he reached the gorges leading to the Kanimbla Valley and the Cox River. In 1813 Blaxland, Wentworth, and Lawson succeeded in reaching the western slopes at the head of the Cox River (near Rydal). They kept to the upper levels of the deeply dissected plateau, and though at Katoomba this is only a mile or two wide (between gorges 2500 feet deep), they found a practicable route for stock. To-day the main Western Railway closely follows their route, and western traffic is still practically confined to this one highway for 50 miles north and 50 miles south of Sydney.

In 1797 Shortland discovered the Hunter River and found the outcrop of coal which determined the rapid growth of Newcastle. Here is the site for a town which possesses all the advantages lacking at Sydney. A

fine stream leads inland to a broad open valley which penetrates to the interior by the lowest gap in the Highlands from the Darling Downs to Western Victoria. This has been named the *Cassilis Gate.*

The river alluvial around Maitland is some of the most fertile in

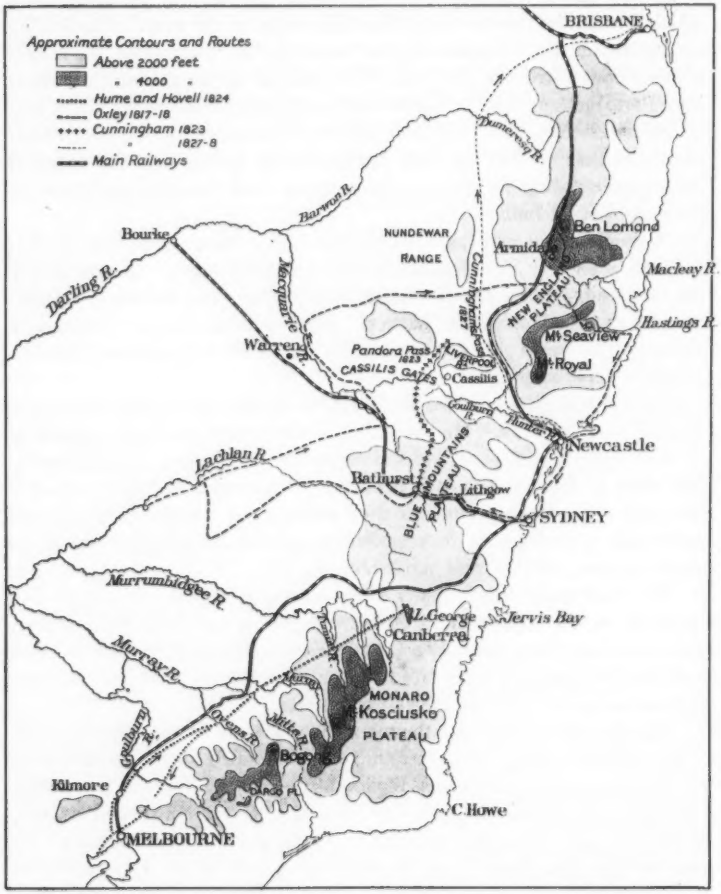

Fig. 5.—Contours of South-East Australia, showing the Cassilis Gate.

Australia. The coalfields are among the richest in the world, and will inevitably place the closest settlement of the future in the vicinity. Thus the Broken Hill Corporation has chosen this locality for much of its manufacturing in spite of the distance from its headquarters, and many other industries are similarly influenced. It is an interesting speculation as to

the size our largest city would have reached had it been placed in this region of infinitely greater economic importance.

The whole east coast of Australia has been determined by folds or fault-planes, which have resulted in the loss of a great tract to eastward in comparatively recent geological time. The steep coastal slopes with the heavy rainfall are everywhere seamed with swiftly running streams. These are dissecting the region—cutting deep valleys back into the hills and producing in favourable regions great canyons, such as those of the Blue Mountains and of New England.

The western slopes of the Highlands were reached by Evans in 1813, and were found to lead gently towards the interior. There are here but few of the great fold and fault planes which have truncated the eastern limbs of the Highlands. The rivers flow less rapidly, but, on the other hand, are often dry from the increasing aridity as we move westwards. The next twenty years of exploration were struggles against an unfamiliar environment, characterized by an inland drainage and an erratic rainfall.

In 1817 Hamilton Hume pushed to the south-west from the settled regions and discovered Lake George and the second Gate across the Highlands. The physiography of this interesting region can be better treated when we deal with his chief expedition in 1824 to Port Philip.

Oxley, in 1817 and 1818, had determined the character of our inland rivers. Both the Macquarie and Lachlan he found to leave the Highlands about 150 miles from the east coast and to traverse the plains without receiving any further important supplies of water. Gradually they decreased in volume and were lost in the marshy swamps of the interior. He was, in fact, entering a region undergoing the early phases of a cycle of arid erosion, and with this type of country an Englishman was naturally unfamiliar.

In 1818 he descended the valley of the Macquarie, and then marched almost due east towards the coast. Here he reached the New England Plateau, the chief massif of the continent. Ascending this granite horst he found himself confronted by the gorges of the Macleay River. Here the waters plunge from the plateau down such falls as the Apsley until they flow in gorges 3000 feet deep cut in the granite scarp. Finally they ascended Mount Sea View, and were rewarded by a sight of the Pacific. They managed to descend the scarp at the head of the Hastings River (which is still quite unsettled, and as rugged country as anywhere in the continent), and so reached the sea at Port Macquarie.

In 1823 Cunningham, starting from the chief inland settlement at Bathurst, marched across the head of the Goulburn River (and so traversed the Cassilis Gate), and passing through the Pandora Pass reached Oxley's Liverpool Plains. In 1827 he marched up the Hunter River and crossed to the plains by the Murrurundi gap, where now the northern railway crosses the divide. No important route has ever followed up the Goulburn River, though it is difficult to see the reason

for this omission. The traffic from the coast to the west all climbs the unusually steep grades of the Blue Mountains (following Blaxland's route) to a height of 3503 feet near Lithgow. A route never rising to 2000 feet is available *viâ* Cassilis Gate; but, presumably because it would favour Newcastle and not Sydney, it has not yet been made use of.

Hume and Hovell started in 1824 from Lake George to reach the coast of Port Philip. Marching more or less parallel to the coast they kept within the region of good rainfall, but the topographic difficulties were at first of a somewhat special nature, for in this corner of Australia is developed an extensive series of fault blocks. The numerous streams which they crossed—the Murrumbidgee, Goodragdigbee, Tumut, upper Murray, Ovens, and Gouldburn—probably all flow along ancient fault valleys occupying strips of the crust which have "foundered" relatively to those adjoining them. They returned through the Kilmore Gate, which is a low gap (only 1000 feet above sea-level), putting Melbourne in easy communication with its hinterland, and in that respect far enhancing the value of the city for a State capital as compared with Sydney.

In 1829 many rivers had been discovered, all flowing to the west. No large estuary had been observed anywhere round Australia which seemed adequate as an outlet for all this water. We can understand, therefore, that there was a general belief in a large inland sea. Thus we find Wentworth writing of this unknown portion of the Macquarie River: "If it should be found to empty itself into the ocean on the north-west coast, which is the only part of the vast island which has not been accurately surveyed, in what mighty conception of the future power and greatness of this colony may we not reasonably indulge? . . . Its course cannot be less than five to six thousand miles."*

It is probable that the Macquarie's course was actually determined by a huge mediterranean sea to the west. In Cretaceous times such a sea occupied east central Australia. The Bogan, Macquarie, Namoi Gwydir, Macintyre and Condamine all head to the north-west instead of to the south-west (to which they ultimately drain).

Later all this area became dry land, and a region of subsidence developed in the south-west at Lake Eyre and all round the lower Murray.

Probably the Lake Eyre drainage scheme reproduces the old early post-Cretaceous systems, but the rivers in the south-east were later deflected to the large Murray Sea. The highland rivers have all been greatly affected by late or post-Tertiary capture. Most of them originally flowed to the west, and have been captured by younger obsequent rivers which drain the faulted coastal slopes.

Mitchell and Sturt cleared up the mystery of the drainage of south-east Australia in the period 1830 to 1836, and showed its general resemblance to the Nile Basin. The Murray rises in well-watered regions, and

* See the graphic account given by Favenc in 'The History of Australian Exploration,' to which I acknowledge my indebtedness for much of my chronology.

receives many tributaries in its upper course, some of which are fed with melting snow for a large part of the year. It gradually enters a region of lower rainfall (15 inches at Echuca, 12 at Wentworth, 10 at Morgan); and after the entry of the Murrumbidgee it only receives one tributary (the Darling) in the whole lower 800 miles.

In 1836 settlement started in South Australia, and exploration pro-

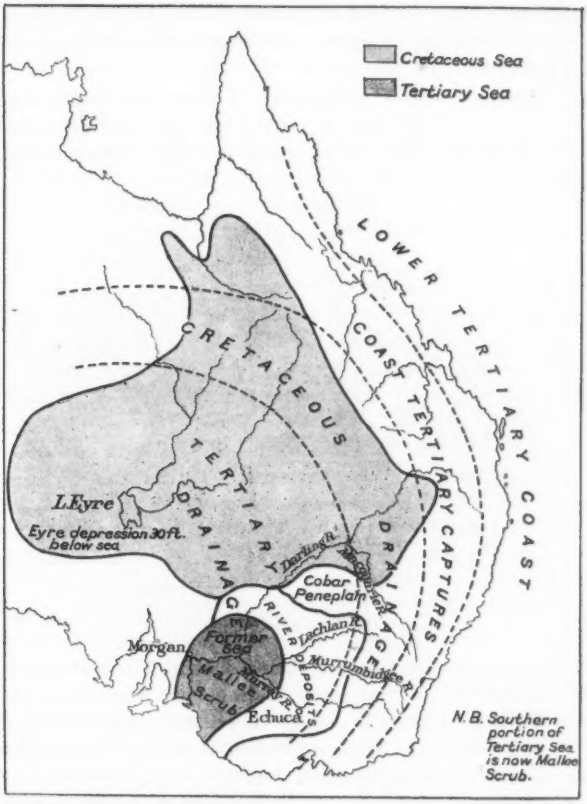

Fig. 6.—Generalized scheme showing the four drainage belts of different drainage origin in Eastern Australia.

gressed rapidly from Adelaide. Eyre's first trip (1838) from Melbourne, with cattle to the new centre, was blocked by the mallee scrub and sand-ridges. These peculiar outposts of the desert occur in a comparatively well-watered region in the north-east of Victoria. They are partly clothed in tea-tree and dwarf eucalyptus, but here and there gleaming white dunes are drifting south under the dominant northerly winds. They

perhaps corroborate Penck's hypothesis, that desert conditions are migrating southward in our hemisphere, whereas the northern limits of the deserts are being reclaimed by Nature herself. However, large areas of the mallee have been successfully devoted to wheat in recent years, where the rainfall reaches 12 inches per year.

The great problem in South Australian exploration was entirely due to physiographic conditions. Eyre saw Lake Torrens in 1838, and a little later from Mount Hopeless he saw similar sheets of water to the east. Hence a horseshoe cordon of salt lakes seemed to cut off Adelaide from the interior.

Lake Torrens occupies a rift-valley of fairly late origin, while the Lake Frome series of salt lakes seems to have been dammed back by the comparatively recent uplift of the Flinders range. There seems little

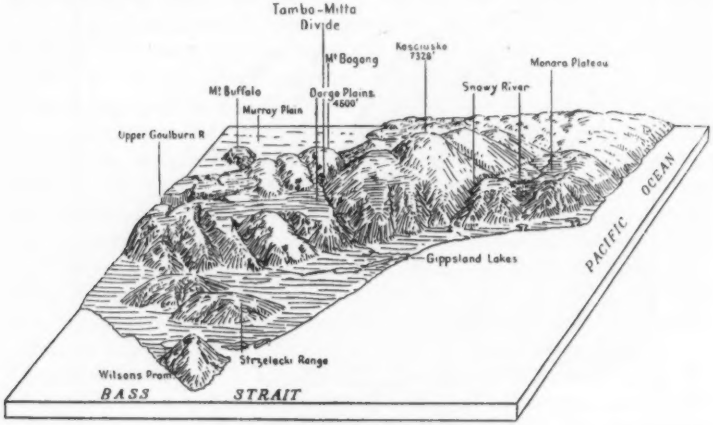

Fig. 7.—The Australian Alpine region.

doubt that the inland rivers Barcoo, Strzelecki, and Siccus flowed directly southward to the ocean before their lower courses were raised 1500 feet by a Late Tertiary buckle of the crust. Howchen has shown that a "fossil river" extends from Lake Frome to Wakefield—*viâ* the river Siccus and over the divide at Orroroo—which furnishes evidence in the form of hundreds of feet of river gravels of the importance of these extinct meridional rivers. Local settlers inform me that in time of flood the Strzelecki feeds Lakes Callabonna and Frome, and also Lake Blanche (as in 1906). Lake Gregory is separated from Lake Blanche by sandhills 25 feet high, and there has been no communication for many years.

Between Lake Gregory and the Barcoo River, a distance of only 20 miles, lie stony rises of desert sandstone from 60 to 100 feet high. The Barcoo when in flood covers a large portion of the eastern shore of Lake Eyre, which is 30 feet below sea-level. The recent official topo-

graphic map of the State shows a broad gap some 30 miles wide (and all less than 500 feet high) between Lake Eyre and Lake Torrens. Thus two slight rises—both of late geological origin—are the chief breaks in Eyre's horseshoe cordon which barred off the South Australian Hinterland.

In 1839 McMillan started from the Monaro plateau, which had been settled for a dozen years, and marching south crossed the Snowy River and reached the Buchan River. A little later he established a new station on the Tambo River, and followed it down to the Gippsland Lakes. Here he was traversing one of the most striking "lineaments" in Australia. This fault-plane cuts right through the highlands, and has led to the capture of the Tambo by the Metta to the north. It still forms almost the only road through these highlands.

In 1840 Count Strzelecki ascended the Alps and named the highest point Kosciusko. He then followed McMillan's tracks across the faulted highlands to Gippsland. He traversed this fertile alluvial region, and passing round the Jurassic Highlands which bear his name, he reached the site of Melbourne without much difficulty.

In 1841 Eyre, who had recently discovered Lake Torrens, started on his disastrous journey to reach the "Swanland" region. He traversed a region comparatively well supplied with rain, and where moreover the rainfall is reliable, though under 10 inches. But the geological conditions were unusual, and contributed largely to the dangers of the party. For over 500 miles the surface of the Millarbor Plains is formed of Tertiary limestone, into which all rain sinks as soon as it falls. This characteristic has greatly hampered the construction of the Trans-Australian railway which now parallels Eyre's route—some 60 miles to northward. Moreover, late subsidences in the Bight have produced one of the most inhospitable coasts in the world, and for hundreds of miles there is no harbour, as noted earlier in this paper.

In 1844 Sturt made his gallant attempt on what is probably the least attractive portion of Australia. It certainly has the lowest rainfall, for near Lake Gregory this is only 5 inches per annum. He left Adelaide and marched up the Murray and Darling to Menindie. Then he turned to the north-west and passed close to Broken Hill. He carried his boat—to traverse the hypothetical inland sea—to Depot Glen near Mount Poole. Here died Poole, one of the party, and here Sturt was held up for six months until one of the rare tropical-trough rains (the only source of rain in these regions) fell in June 1844.

He discovered the "gibber" plains (Sturt's Stony Desert) between the Barcoo and the Diamentina. These "gibbers" are jasper-like fragments of the disintegrating Cretaceous cover of the great Artesian Basin. He reached the real desert sand-ridge country, and in fact penetrated the true home of King Drought.

Here—on the Strzelecki which Sturt explored—was built in later years Birkett's wool-shed, and for some years twenty thousand sheep were shorn

at a time. But in 1916 it had passed to its former barren state, and according to E. R. Waite only a single post remains of this flourishing centre. The variability of the rainfall is as important a factor in exploration and settlement as the annual average, and has led to more disappointment and financial loss than any other of our disabilities.

In 1844 Leichhardt started on his famous journey through Queensland

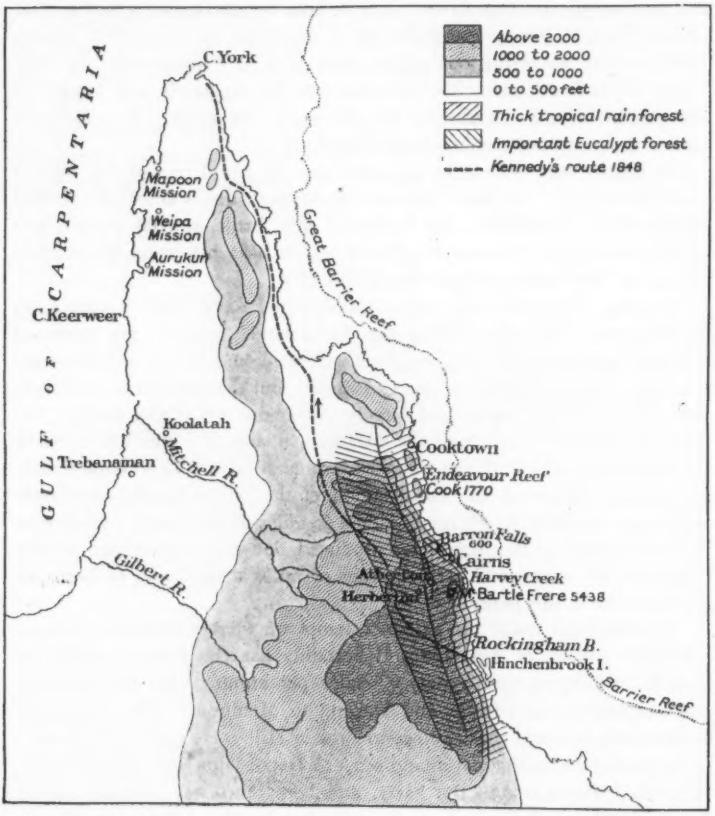

Fig. 8.—The Atherton Plateau, with its forests; and Kennedy's route.

and Northern Territory. He traversed well-watered country for the most part, and met with little difficulty even from aboriginals until their attack near the Gilbert River (on the Gulf) where Gilbert was killed. He explored, however, some of the most puzzling country in Australia. The sketch-diagram shows how confusing is the drainage in the Fitzroy Basin (and the Burdekin is very similar). The actual divide is much less striking than the coastal ranges, which rise to 2548 feet in Double Mountain,

north-west of the Fitzroy estuary. The dismembered ancient upper portions of the western rivers are now linked to the coastal systems, *e.g.* Dawson, Comet, Nogoa, etc.

Mitchell explored further west in 1846. He named the Nogoa—because it was "no go" as a route to the north coast; and the name of the Belyando (a little north) is said to be an aboriginal phrase with the same meaning. The Great Divide is here largely a late crustal warp. Lava-flows have helped to form it, and small lakes and "boathook bends" show its recent origin.

In 1848 Leichhardt started on his last journey to the north-west. It has been surmised that he reached the Elsey River in Northern Territory, but no authentic relics of his party have been found. There is no doubt that was vanquished by the uncertain character of the inland rains.

In almost all tropical lands the too luxuriant vegetation is one of the chief factors impeding exploration. Such a flora is lacking throughout Australia, except for a mere fringe along the east coast. It contributed, however, to the tragic end of Kennedy's expedition in 1848. Kennedy was ordered to explore the Queensland coast north of Townsville and to make his way to Albany on Cape York. In this region is without exception the grandest coast scenery in Australia. Here are the chief waterfalls and the finest gorges. Here the rivers rise *on the coast* and flow westward; and here, and here only, is a tropical plateau rising to 5000 feet and clothed in dense lianes, lawyer vines, palms, and tropical vegetation akin to that of the Malay States.

Had Kennedy's path been further to the west, he would have passed through much more open country, instead of which he had to cross a deeply dissected scarp in which the "youngest" streams in the Commonwealth are busy notching their valleys. He gradually lost his transport animals. The numerous aboriginals of this productive corner of the continent dogged his steps, and finally only three of the thirteen men were rescued from death. Here the rugged topography, due to the recent submergence of the eastern slopes of the highlands, was one important factor. The heavy rainfall, amounting to 165 inches a year at Harvey Creek, due to the constant on-shore trade-winds, was another physiographic factor which directly contributed to the disaster.

In 1859 Stuart attacked the central regions of the continent, considerably to the west of Sturt's explorations. He was fortunate in coasting the edge of the artesian sea—where its overflow appears as numerous springs, of Hergott, Coward, Strangways, etc. Thence he entered the riverine region where the drainage of the Macdonnel Ranges flows toward Lake Eyre (the telegraph line follows his route). Here the evolution of the land surface has led to great rocky gorges in the ranges, in which there are deep permanent pools, and where relics of the pre-arid flora (such as the Livistona palm) have just escaped destruction. To the north the mulga scrub defied him on two expeditions, but he reached the sea *viâ* Adelaide River on 24 July 1862.

By 1862 the whole of Australia was fairly well known—except for a solid block in the west, bounded approximately by lines from Broome (West Australia), south to the Bight, east to Lake Eyre, and north along the Overland Telegraph to Victoria River in Northern Territory. The Fitzroy and Sturt rivers had been traversed—but elsewhere it was *Terra Incognita.* The primary control here is sheer lack of water. With an

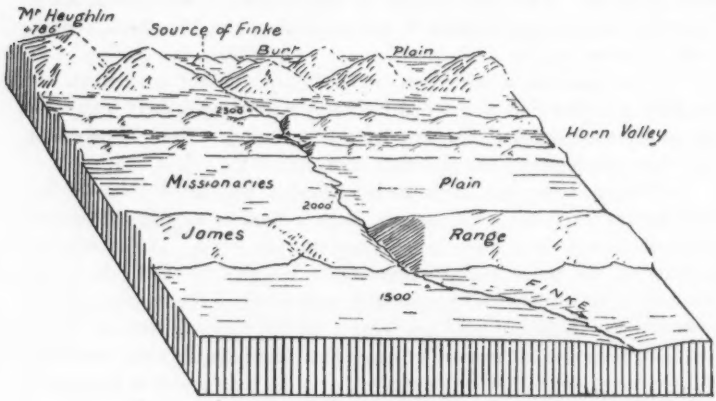

Fig. 9.—The structure of the Central Australian Highlands.

evaporation of over 100 inches per annum, a rainfall of 10 inches is not of much consequence. Worst of all, however, is the *uncertainty* of the rainfall. In the following table I give the rainfall in *two successive years* for a number of places in the region which last defied exploration :—

VARIABILITY IN AUSTRALIAN RAINFALL (SUCCESSIVE YEARS).

Place.	Average annual rain.	Year.	Total in inches.	Monthly totals (inches).
Barrow Creek (N.T.) ...	12·1 inches	1904	38·9	March 13·42
		1905	3·8	,, 0·48
Alexandra (N.T.), (Barkly Tableland)	15·1 ,,	1902	5·7	March 0·1 Dec. 1·6
		1903	34·0	,, 18·6 ,, 10·7
Borraloola (N.T.), (near the Gulf)	28·0 ,,	1899	46·9	Jan. 12·9 Mar. 29·1
		1900	9·1	,, 4·9 ,, 0·5
Wiluna (W.A.)	10·4 ,,	1900	28·0	April 20·8
		1901	7·7	,, 0
Nullagine (W.A.)	12·7 ,,	1911	6·9	March 0
		1912	18·3	,, 10·1
Onslow (W.A.)	9·0 ,,	1900	27·0	April 11·0 May 10·2
		1901	2·6	,, 0 ,, 0·5
Charlotte Waters (S.A.) ...	5·4 ,,	1908	12·3	March 4·9
		1909	2·8	,, 0·0
Kanowana (S.A.)	4·1 ,,	1910	8·7	Nov. 0·5 Dec. 0·0
		1911	13·6	,, 6·0 ,, 3·1

This, then, is the explanation of the very varying accounts given by different explorers of the same region. The logical course is to consider the reliability of the rain in addition to its average annual rainfall. Such a "reliability" map is here given. We see that only along the south is the inland rainfall at all reliable. It encourages the hope that the Trans-Australian Railway will be found to traverse country more useful than its low rainfall (8 to 9 inches) would at first sight indicate. But it gives us no encouragement as regards all the rest of the arid interior and of the Barkly Tableland region in the north.

The magnificent journeys of Warburton, Forrest, and Giles in 1873–6

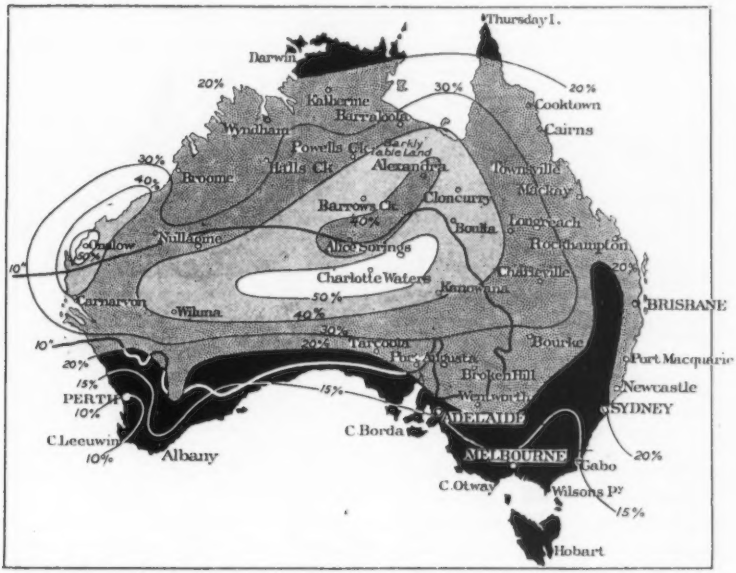

Fig. 10.—Rain reliability for Australia: Percentages show average deviation from the mean.

only served to show how little Australia has to expect from this inner western region. Apart from the goldfields settlement (in the south-west corner of the arid region), which is maintained by mining and largely dependant on a colossal scheme of artificial water-supply, there is hardly a settler to this day. The three explorers cited all travelled along the parallels; but in 1896 two parties under Wells and Carnegie respectively cut across their tracks, starting from the goldfields and marching north.

All gave the same report of everlasting sandhills, sparsely covered with spinifex and scrub, interspersed with mulga flats. Surface or shallow-well water is usually obtainable in small quantities — as the line of Canning's wells (from Wiluma to Hall's Creek) shows. But there is only

scanty feed for cattle or sheep in the best of it; and Talbot has reported adversely on the mining possibilities of the less-known northern portions.

The *reliability* of the rain rather than the annual average controls the arid vegetation. Thus we find that the worst grade of country—the sandridge and spinifex type, which caused the deaths of Gibson, Poole, and other well-known explorers—occupies the north-central belt. The most arid belt (below 10 inches) has a more southern position, and the southern fringe of this (outside the 30 per cent. variation isopleth) is mallee country, capable of being fairly well stocked now that the railway is built.

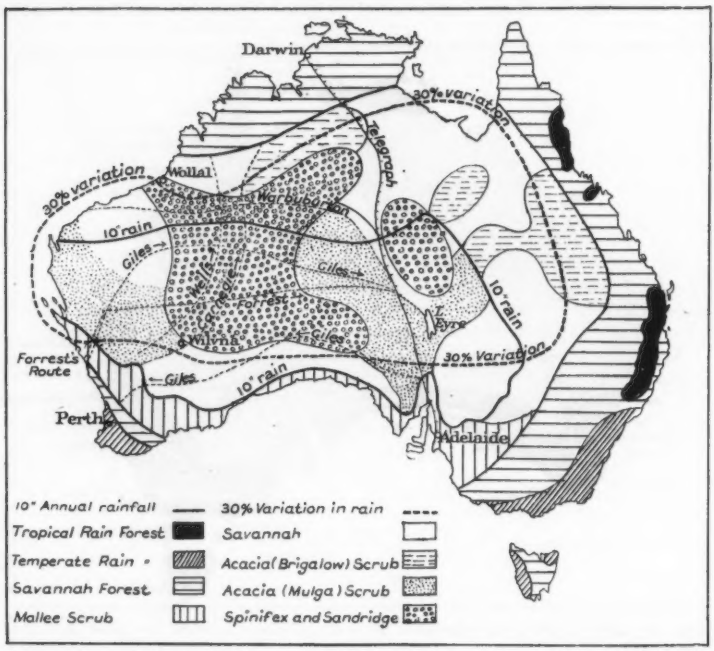

Fig. 11.—Generalized vegetation map and rain reliability, with special reference to the Sandridge and Mulga country.

Climatic factors have determined that Australia shall be primarily a pastoral country. Some 1,000,000 square miles (the sandridge and mulga regions), or one-third of the whole, unfortunately only offers poor sustenance to stock. There are probably less than 150,000 cattle and sheep in all this extent of country, which is not much more than 1 per cent. of the total stock of the Commonwealth. This arid region is obviously totally unsuited for *close* settlement.

It seems likely—though the "practical" stock-owner will greet the opinion with contempt—that economic climatology is a better guide to

the future of Australia than the experience of the "man on the spot," which experience may have been limited to a series of unusually good seasons.

Let us therefore profit by the example of our most successful explorers, especially in two directions. They made careful study of such data as were available—in effect, they had an un-British belief in the value of "taking thought for the morrow." Furthermore, they did not fear grave difficulties, but faced them boldly. Our national future in Australia is fraught with great difficulties, though many would have us deny or conceal them. Little is gained by shutting our eyes to the disabilities of our arid interior and northern tropical lands. It is as much to the national interest to study the controls governing the less-favoured areas, as it is to invite attention to our prosperous centres of close settlement.

Before the paper the CHAIRMAN (Dr. AUBREY STRAHAN) said: The paper this afternoon is on the Pysiographic Control of Australian Exploration by Dr. Griffith Taylor, who is in Australia and therefore unable to read his paper. Captain Sir Douglas Mawson has, however, been kind enough to undertake to give us the paper in Dr. Taylor's absence.

In giving an account of the paper printed above Captain Sir Douglas Mawson added the following remarks, and a discussion followed.

Captain Sir DOUGLAS MAWSON: Many areas in Australia suffer long drought, in some six months or more, and this is one of the most awkward factors of the country. Near the coast the rainfall is fairly uniform throughout the year; that is to say, one can have a good fall of rain in any month; but in the central part there is always a long period of drought. In the north drought occurs in the winter; in the south during the summer; the rains in the north being monsoon rains. The word "Abrolhos" is supposed to mean "keep your eyes skinned"; it is probably a word of Portuguese origin, not Dutch; but it may be that the Dutch have copied it as a sailors' term from the Portuguese navigators of the time. The fine region in the south-west has been divided by Dr. Taylor into zones typified by various types of gum trees, and it is a good method of trying to ascertain the probable rainfall in Australia, to keep careful note of the vegetation, for different trees live in different conditions of rainfall.

The coast in the Sydney region is a comparatively low plain leading up to a steep rise and a high plateau of mountains that were a barrier to the spread of settlement, for the crossing of these mountains was not so easy as the crossing of ordinary mountains of anything like the altitude of 3500 to 5000 feet, because the valleys, which are the natural roadway into new country, are here of a peculiar type: bottle-necked, steep-walled valleys, almost unique. Standing on the brink of these valleys one looks down into something like the Grand Cañon of Colorado, with falls of over 3000 feet sheer, so that any one entering those valleys might get to the head, but not be able to get out at the top. The Kanimbla Valley is large, but when it comes down to join the Wollondilly it narrows to a gorge filled entirely with water, and it is difficult to get through. All the other valleys are the same, so that the early explorers attempting to go

inland were repulsed. Prof. David of Sydney has done most towards finding an explanation. Although this is a plateau region, there is a main throw-down, mostly as a monocline. The rocks incline until they are almost vertical. Overlying the softer coal-bearing and other shales there is a series of sandstone. This sandstone is very hard, and the rivers find it difficult to cut their way through, but when once they are through they eat away the softer rocks below. That factor produces the bottle-necks.

During the last twenty years there have been many small expeditions for mine prospecting in the little-known interior. Two or three men with a few camels have gone out and done wonderful work, being away two or three years, very little having been heard of them, as it does not get into print. There is not much of that area that is likely to have anything very exciting in it, or these prospectors would have discovered it. Forrest and others showed what a desolate country most of it is, and, in the larger part of the area in the north where there is no sand, there is what Carnegie called a territory of spinifex, a clumpy sort of grass rather spear-like and not much use for anything.

One of the biggest factors in the occupation of the country is not so much the average annual rainfall as the possibility of getting no rain at all, and making up the average a few years later ; but if all the stock has died in the mean time it does not much matter whether you get rain later to make up the average.

With regard to vegetation, the mallee is a very common feature over a large area of Australia. It is a small eucalypt with an enormous bole and a root which seems to store a good deal of water. The savannah area extends around the east and south coast ; then there is the spinifex region, of which there is not a great extent ; for the rest it is country useful for sparse population. Stock do excellently, if they are few to the square mile, and the merino sheep do better in this country than elsewhere. Dr. Taylor certainly draws attention to the disabilities of Australia in those arid regions, and shows how this aridity in the west led to Great Britain now owning Australia and not the Dutch. But although only 1 per cent. of Australian stock is being run on one-third of Australia, yet there are minerals in this area. The richest iron ore in the world occurs in patches, which are unfortunately a long way from the coast. If Great Britain wishes to push the steel industry, I think she could just as profitably push it in Australia as in Spitsbergen. Australia is British ; it is a good climate, especially in the south. Moreover, there is a movement on foot at the present moment towards making Australia a great iron-smelting country, and a tendency for Australia to supply steel not only to Australasia, but to the Dutch East Indies, to Japan, to South Africa, so that there are reasons why British capital should be spent in steel development there, even in preference to importing steel ores into Great Britain and smelting them. I think some of the companies in this country would do well to consider Australia from this point of view.

The CHAIRMAN : I think Sir Douglas Mawson has given an admirable account of an exceedingly complicated subject. The paper is full of information of all sorts, and deals with an enormous tract of country. I admire the patriotism with which Captain Mawson stands up for his country ; but I can assure him that he need not be jealous of Spitsbergen's iron resources. Unfortunately, the disabilities of Australia to which he refers are such that it is beyond the power of man, even modern man, to remedy. We cannot change the trade winds or the physiography of a continent, and we cannot change the geological constitution of a tract of ground like that. All such things appear to have their effect upon the physiographic conditions of

Australia. In one case we notice that the extent of limestone covering a large tract of ground had an important influence on the climate or, at any rate, on the water conditions of that tract. I was greatly interested in the description of that mountain range near Sydney, which appeared to me to be rather like our own little area of the Weald. There you once had the chalk forming a ledge over it, so that in the formation and excavation of the Weald the valleys must have been gradually opening themselves out in the way we see in the mountains of Australia, the rivers flowing through narrow gorges in the chalk on each side. It is the old story—a river in soft strata makes a valley, in hard a gorge. That region near Sydney seemed to me to represent a stage through which our own little Wealden area must once have passed. It suggests that these mountains near Sydney are of quite recent geological formation. Blockfaulting is a very delicate question. It is very easy indeed to say what was once said of our Wealden area, that all the gaps by which the rivers escape are due to faults. There was only one failing in the theory: when the ground was carefully examined and mapped there were no faults there. I am not going to say for a moment that these block faults do not exist, and it would be very dangerous to speak dogmatically about country I have never seen and know nothing about. I do, however, venture to say that a theory of that kind should be subjected to very careful criticism before it is accepted as an axiom.

A FELLOW: There has been something in the newspapers during the last few days with regard to an expedition of motor-cycles and aeroplanes right across Australia. What is the object of that expedition? Is it to facilitate the opening up of the country? Is there any idea of building a line from Port Augusta right up north to Port Darwin?

Captain Sir DOUGLAS MAWSON: I do not know anything of that expedition, except that I have seen in the papers it is proposed to start a company to run aeroplanes to London, and I expect they are proposing to send some scouts ahead to map out a good route across the continent. I do not think they would go north from Adelaide, but straight from Sydney to Port Darwin. That is probably the line of the next railway, not from Adelaide to Port Augusta. Many years ago when that railway was started the South Australian Government were most anxious to run to Port Darwin; but the other States have been keen to put money in it, and consequently when that line does come it is to go through Perth. The dry country is pastoral, and within a few weeks of a good heavy rain what was almost bare ground, with an occasional tuft of spinifex or salt bush, becomes waving grass as high as a horse's thigh. When there is a good season in one part you put the maximum stock on the pastures for the time being, and then get your stock away when the drought is coming. You have to know the region, and to move the stock quickly when necessary. In the old days when there were no railways, when the drought came after a series of good years, the squatter thought he could go on with the same stock, but he was suddenly faced with drought. Perhaps he thought it would be better the next year and kept the same number of stock on, and they probably ate the place out, and then when the drought arrived there was nothing to give them. You can cut down the limbs of trees and feed the stock on the leaves, but that will not last for two or three years. With the spread of railways, as the seasons change you can shift your stock away to another part, where there is a good season, leaving only a small amount of stock behind. Many squatters have property down near the coast and far inland; they can keep half the stock inland until the drought approaches, and then

they rush it down to the coast. Railways will improve possibilities for stock-keeping in Australia.

The CHAIRMAN: It remains for me only to express on your behalf to Dr. Taylor thanks for his paper, which I think has been of great interest, and especially I will ask you to record your gratitude to Sir Douglas Mawson for his exceedingly able exposition of the subject.

REVIEWS

ASIA

Asia Minor.— Walter A. Hawley. London: John Lane. 1918. *Map and Illustrations.* 12*s.* 6*d. net.*

A STUDENT of Asia Minor glancing through this volume for the first time is likely to do so with curiosity. He will be anxious to learn just how, within the compass of three hundred pages of bold type and ample margin, the author has contrived to cover the gigantic subject propounded by his title. One hopes to find, maybe, a broadly handled sketch, in which a long and involved but fascinating story shall have been reduced to a clear and orderly outline; one finds, instead, little more than a loose collection of travel impressions, by railway and steamer, along some of what may be called the chief tourist routes of Asia Minor. With disappointment one realizes that here is a book quite overweighted by its title.

The opening chapter sketches briefly the physiography and history of Asia Minor, and is well enough, considering the complexity of both subjects and the true nature of the book. Thereafter the author goes upon his travels, and sees something of the country, its cities, peoples, and strange sights, including performances by howling dervishes and whirling dervishes; he gives, also, some general information upon certain districts that he did not visit. He journeyed first from Constantinople to Brussa, capital of the early Ottoman conquerors; then by steamer, from Constantinople again, through the Ægean to Smyrna. From Smyrna he visited the four great classic valleys of Western Asia Minor—the valleys of the Mæander, Hermus, Cayster, and Caicus; wandered over the sites of the ancient cities of "The Seven Churches which are in Asia;" and examined ruins laid bare by the excavations of archæologists. He went to Konia (St. Paul's Iconium) and to Karaman, both with interesting remains of Seljuk art, and also to Angora, far in the interior. And then, as final journey, he took steamer from Constantinople along the southern coast of the Black Sea, calling at various places on the way, and so came at last to Trebizond.

It makes a long itinerary, through a varied and always attractive country, rich in every sort of historical association. The author, further, is obviously in love with his subject. But he is over-anxious to give full details to his readers; his descriptions of scenery, architecture, and archæological discoveries are generally too precise and much too long; they produce confused pictures. He tells us what he saw and felt, but too often fails to get beneath the surface; and, in spite of his sympathy and good purpose, the subtle charm of the country escapes him. Something of this failure may have been due to shortness of time and the exigencies of travel; but more, one suspects, to the disturbing influence of the author's Greek friends and travelling companions. As *cicerone* in Asia Minor, your well-to-do Greek is an intolerable distraction; for him the East of romance and colour and old survival does not exist; he sees only a

dreaded, fanatical barbarism, qualified by nothing but political opportunity for his race and commercial opportunity for himself. The East, in the narrower geographical sense, is Moslem; and he who would understand and convey with truth its scenes and spirit must go without intermediaries to its Moslem people.

The author shows us now and then what he is capable of when free from disturbing company; when he goes out alone, lingers over some scene of street or courtyard, or from a hilltop watches summer dawn steal over an old minareted city. Then he sees with insight, and suppresses needless detail in the telling, and gives us excellent glimpses of the country. Of such sort, also, is his description of the Avylon, the great plain of Asia Minor. It reveals for us the charm of that great, bare, and lonely plain, 3000 feet above the Mediterranean; with its far-off blue rim of mountains; its silence, and sunlight, and wonderful atmosphere; and the burning splendour of its stars at night.

The book contains many reproductions of photographs. W. J. C.

AMERICA

Voyages on the Yukon and its Tributaries: A Narrative of Summer Travel in the Interior of Alaska.— Hudson Stuck, D.D., F.R.G.S. New York: Charles Scribner's Sons. 1917. $4.50 *net.*

Archdeacon Stuck, who has spent more than thirteen years in Alaska, is known by his ascent of Mount McKinley and his 'Ten Thousand Miles with a Dog Sled.' In the latter book he treats of several districts described in the present volume, but they were then in their winter dress, whereas the journeys here narrated were performed in summer on a motor launch. The author takes the reader from Lake Lebarge, at the foot of White Pass, down to the mouth of the Yukon, and in the second part relates his experiences on some of the great tributaries, the Porcupine, Tanana, Koyukuk, etc. He gives a very good general description of these rivers from his own observations, adding many interesting details about the headwaters beyond the limit of navigation, which were told him by prospectors and other wanderers. Gold-mining, of course, cannot be passed over, and we hear of rushes to one mining district after another, of towns springing up and decaying when the placers are exhausted. The natives, Indians and Eskimos, are naturally of prime interest to the author. He considers them to be on the whole peaceable and tractable people, capable of considerable development under favourable conditions, and blames the Government for not enforcing more strictly the law against the sale of alcoholic liquors to the natives and in other ways neglecting their welfare.

Some of his remarks on the fauna and flora are of value, especially on rabbits and salmon, but when he affirms that young salmon, returning to the river after thirty months, make their way to the same tributary and even the same brook where they were spawned, we wish he had cited the proofs. He is puzzled by the fact that the Yukon, after emerging from the rapids in the Ramparts, presses against the right bank during its course, mostly south-west, to the sea. Of course, the rotation of the Earth would cause it to do so, but the change of latitude is small, and probably the westerly momentum of its water is the chief cause, for the Yukon is a rapid stream and flows for a long distance in a generally western direction.

The book contains a number of good illustrations and a map of Alaska.

W. A. T.

GENERAL

The Wild Life of the World: a Descriptive Survey of the Geographical Distribution of Animals.— R. Lydekker, F.R.S. Illustrated with over six hundred engravings from original Drawings and one hundred and twenty studies in colour. London: Frederick Warne & Co.; and New York. 1916 [1918]. Three volumes. 84*s. net.*

This work comes from the pen of a distinguished man of science, Richard Lydekker, who died while it was passing through the press, at the premature age of sixty-six, in 1915. It had, however, "received his final revision, so that it remains as he left it." The land animals and in a more limited degree marine animals "are considered here in connection with their geographical distribution on the surface of the globe"; but as the method of technical treatises "does not readily lend itself to a work on thoroughly popular lines, in the present work the ordinary geographical divisions of the land surfaces of the globe have been followed to a great extent, and the faunas of the continents described in that order." The fauna of Central Europe is treated according to its "stations," *i.e.* whether dwelling in the woods, the open country, farm and garden, lakes and streams; then succeeds that of Northern, Alpine, Eastern and Southern Europe, to form Volume 1. Volume 2 deals with the fauna of Asia (under Arctic Asia, Siberia, South-Western Asia; Caspian Area; India; the Malay Province; the Malay and Philippine Islands; the Chinese Province); with that of the Northern Seas, and that of America (Arctic and Canada; United States; Tropical America; Patagonia and Chile; West Indies and the Galapagos Islands). Volume 3 describes the fauna of Africa (Northern and Ethiopian; Madagascar; the Mascarene, Comoro and Seychelle Islands); that of Australia, New Guinea; New Zealand; Polynesia and Hawaia; and finally, that of the Southern and Eastern Oceans. These volumes form a companion work to the 'Royal Natural History,' which Mr. Lydekker edited, and wrote in great part. "The species described are regarded as a rule in a wide sense, so that many of those named by modern naturalists [especially ornithologists] on the evidence of slight distinctions"—it might well be affirmed on infinitesmal differences very often unrecognizable by other than their describers—"are ignored." The animals noticed from the various regions—taken more or less in systematic sequence—are described in delightfully popular but quite scientifically accurate terms, and at greater or less length according to their importance in denoting geographical or geological changes. 'The Wild Life of the World' may best be described as an excellently condensed 'Royal Natural History,' in which the species are reviewed, some of them rather perfunctorily, according to geographical regions; but as an account of zoological geography this method of arrangement affords a less satisfying, if not a rather confusing view to the unscientific reader.

Each of these geographical areas is prefaced by a *résumé* of its characteristic features, biological, geographical, geological, and (chiefly where the inhabitants are uncivilized) ethnological, written with admirable skill and judgment, as might be expected from an author whose knowledge of all these departments was truly encyclopædic. Indeed, for a single zoologist to have described practically all the most important mammals, birds, reptiles, fishes, and invertebrates of the world, with, on the whole, such condensed accuracy and with so much literary grace, is unquestionably an extraordinary performance, if indeed Mr. Lydekker be responsible for the whole book, and nothing to the contrary is indicated in the Preface or Title-page.

The most noticeable slip—among the few, detected by the writer, that have escaped the author's eye—occurs in volume 3, p. 218. The Tasmanian wolf "has of late years been made the type of a distinct family, the *Thylacynidæ*, the other members of which are extinct and are known . . . from the Middle Tertiary deposits of the Santa Cruz district of Patagonia. If . . . these extinct carnivores, such as *prothylacynus*, are rightly associated with the Tasmanian wolf, it is a most remarkable fact in the geographical distribution of animals and affords practically conclusive evidence that Australia and Tasmania [which should of course read *South America*] were at one time connected with one another by land. The fact that the nearest living relatives of the Tasmanian wolf and the native cats of Australia are the true opossums of South America . . . affords corroborative evidence in the same direction." In a footnote to this paragraph Mr. Lydekker adds: "The writer may be permitted to take this opportunity of mentioning that this view—based on recent increases to our knowledge—is to be taken as replacing opinions previously expressed by himself on this point." At p. 285, volume 3, we read: The distribution of "these curious arthropods (*Peripatus*), which evidently represent a primitive type, . . . serves to support the theory of a former land connection between the Southern Continents." At page 209 of the same volume is the following statement: "In common with those of S. America and Madagascar . . . the rivers of Australia and Tasmania are inhabited by crayfishes belonging to the exclusively southern family *Parastacidæ*. . . . The distribution of this group of crustaceans is singularly like that of the side-necked tortoises and the boa group of snakes; and in this case, at any rate, affords strong support to the theory of a former land connection between Australia and Madagascar on the one hand and South America on the other." These statements, especially in regard to Madagascar, are gratifying to the present reviewer inasmuch as they corroborate—what was much contested then and since—the land connections with that island in the southern hemisphere which he ventured to draw on a map presented to the Society in 1893 (Suppl. Papers, vol. 3).

A word must be said as to the excellence of the illustrations. The studies in colour—painted by a German artist, whose name ought surely to have been acknowledged on the Title-page, but printed in Great Britain—can hardly be surpassed. Two may specially be mentioned. The frontispiece to volume 1, the Fox, is a delightful picture: the rising full moon illuminates the snow and the fox on a hilltop crowned with firs which are incarnadined by the setting sun; and another is the White-handed Gibbon in the act of wailing—a picture so true and speaking that those who know the interesting creature in its home will almost believe they are listening to its doleful voice! The figures in the text are equally admirable, while the typography is faultless.

It will be a deep regret to the wide circle of his friends that the talented author did not live to be congratulated on the publication of this beautiful work.

H. O. FORBES.

The World we Live in.— Edited by **Graeme Williams.** 4 vols. London: The Waverley Book Co. [1915–18.] *With many Illustrations and Sketch-maps.* 8*s.* 6*d. per volume.*

The first volume of this book, reviewed here in vol. 47, p. 379, contains general articles; the remaining three, except for an article by Mr. Arthur Holmes on "The Origin of Land Forms and Scenery," at the beginning of vol. 2, are devoted to the continents and oceans. In its complete form the book presents itself as one of those semi-popular, semi-educational publications,

with a wealth of illustration, with which the enterprise of certain firms has familiarized us in recent years. Its illustrations are frequently striking, and in some of the articles are appropriate and adequately lettered. In other instances their relevance is not obvious, and their lettering does not appear to have been either written or revised by the authors of the articles in which they are inserted. Sometimes, indeed, they overweight the text. It is difficult to understand, for example, why Antarctica should have a whole article to itself, while there is no corresponding one on the Arctic area, save on the ground that it was desired to utilize Mr. Ponting's fine series of photographs.

We have found the general plan of the work difficult to trace, and there is little cohesion between the different articles. For example, Mr. R. J. Finch, writing on the fauna of North America, refers, rightly enough, to Sir H. H. Johnston's general article on animal distribution in vol. I. But contradictions between the two are numerous and striking. Sir H. H. Johnston lays stress on the absence of antelopes in North America; Mr. Finch gives a table in which the antelope appears as a representative North American animal, confined to "Mexico and Central America." If, as is probable, he means the prongbuck, his distribution is wrong, as his co-author points out. Again, Sir H. H. Johnston gives a fairly full account of the distribution of the seals, mentioning especially the Californian sea-elephant; Mr. Finch says that seals in North America are confined to "the frozen north." If inconsistencies of this type are especially numerous in the sections dealing with animals, the reason is doubtless to be found in the fact that Sir H. H. Johnston's article sets a standard which is clearly far beyond the reach of almost all the other contributors, as it must, we think, be beyond that of most readers. Even this, however, is no excuse for the slovenly statements about animal affinities and distribution which appear in the articles on South America and Australia. We note especially the assertion that marsupials now live only in Australia, and that the llama and its allies "represent a curious mixture of the sheep and the deer."

So far as geography proper is concerned, there is a similar inequality of treatment and inconsistency of statement. Mr. Finch gives an excellent account, on modern lines, of South Africa, the article, oddly enough, being divorced from the rest of the continent. South America, similarly divorced from the northern area, is divided between Mr. L. M. Parsons, who gives a general description, and Mr. W. H. Koebel, who follows with a series of popular encyclopædic articles; the two authors both repeat and contradict each other. Europe, sandwiched in between South America and Asia, is discussed by Prof. Grenville Cole, who writes a picturesque account, from the standpoint of the traveller with geological tastes, of various lands, but appears to take a malicious pleasure in ignoring or slurring over the aspects of the subject on which geographers of late years have laid most stress. Thus in the section on the growth of towns no word is said of the importance of a position at a crossing-place of routes, not even in so outstanding an example as Cologne; "rains," we are told, "are not seasonal in Europe, but may occur in almost any month;" south of the *fortieth* parallel "the olive becomes a common tree": these are but a few examples of his indifference to the work of the "moderns."

On the whole, and despite some valuable articles, we fear that the book must find its public chiefly on the strength of its pictures; to the geographer in the making, at least, its text will often prove a snare. M. I. N.

Okeanographia.— J. Shokalsky. Petrograd : A. F. Marks. 1917. *Maps and Illustrations.* 33*s.*

Of all the surprising things which have happened in Russia in the past four years perhaps the most unexpected is the publication of General Shokalsky's finely printed and splendidly illustrated volume on Oceanography. Completed in the years when Russia was still an active ally of the Western Powers, it appeared at the critical period when the Bolshevist party was coming into power. It stands as a monument of the scientific greatness of the old Russia. General Shokalsky has been at work for many years in the Russian Admiralty and in the Physical Geography Section of the Russian Geographical Society collecting data and organizing expeditions, so that his work is original in a double sense, by presenting a new synthesis of oceanographical theory from the original researches of oceanographers of every nationality, and by incorporating for the first time the results of Russian investigations in the Arctic and the Black Seas.

We cannot profess to review the book on account of the language in which it is written ; but we have examined the illustrations and read the headings of chapters and sections which enables us by the further aid of a syllabus in English supplied by the author to realize how fully General Shokalsky has succeeded in his great plan of producing a new treatise on Oceanography. We have long been familiar with his investigations, and both by correspondence and in happier years by personal discussion we knew the lines on which he was working.

The work follows the natural order of the subject, a historical introduction leading to discussions in turn of the distribution of land and water, the depth and configuration of ocean basins, the physical properties of sea-water, the seasonal changes of temperature and salinity, and finally tides, currents, and the phenomena of oceanic circulation.

A two-page plate shows on a single map the routes of all the great oceanic and oceanographical expeditions from the voyages of Captain Cook, through the period of the *Challenger* and its successors down to that of the *Deutschland* to the Weddell Sea in 1911–1912. This map is on Mercator's projection, which is appropriate as it provides space for the polar voyages, which have always been concerned to a large extent with observations on the depths of the sea. Most of the maps dealing with the distribution of deep-sea soundings, deposits, surface temperature, salinity, and the like, are shown in hemispheres each occupying one of the large nearly square pages.

There is something rather exasperating in contemplating this volume, which embodies the researches, the reading, and the original handling of a highly trained and exceptionally competent specialist expressed in a language which places it out of the reach of almost every student who wishes to consult it. Nor can we venture to hope that at such a time as this there is any prospect of a translation or an abstract being prepared in any of the languages which are common to the scientific world. H. R. M.

Tidal Lands: a Study of Shore Problems.— Alfred E. Carey and **F. W. Oliver.** London : Blackie & Son. 1918. *Plans and Illustrations.* 12*s.* 6*d. net.*

In this volume the authors deal with the problems incidental to shore protection, both from sea and sand. They rightly lay stress upon the proposition that the use of vegetation in controlling the wayward forces of Nature lies quite legitimately within the province of the engineer.

The reader is first carried through what may be termed a tabloid course in maritime engineering, which is useful and perhaps necessary in view of popular haziness upon such matters. The authors confess that the chief charm of this important profession lies in its infinite variety and possibilities.

The function of vegetation is next analyzed and its use as a protective agent quite fully discussed. The following chapters take up the subject of the fixation of sand-dunes and shingle beaches by appropriate plants in greater detail. The authors suggest the term "anarhizophyte" for that useful type of vegetation which will survive an invasion of its original habitat by mobile layers of sand and shingle, and is so important as a stabilizing agent. In connection with the subject of the invasion of marsh-lands by vegetation, they call attention to a fact of which the importance is only beginning to be appreciated by botanists and plant-physiologists — the phenomenon of the "bumper-crop," or occasional year of vastly increased activity upon the part of any given species. The eremographer has of course noticed this as applied to the desert flora, where the conditions of existence are commonly hazardous and but seldom entirely satisfactory ; but it is much more striking in the case of the halophytes in marsh-lands, where such elements of environment may be assumed to approach more constantly to the optimum condition for reproduction. Blakeney Point, Norfolk, has been selected for detailed treatment, as illustrative of the whole subject of coastal conservation. The selection is a good one and the example is well worked out. In the final chapter brief mention is made of the Brasher system of compressed-air protection against heavy wave-movement, as developed upon the Pacific coast with such striking results.

The volume is well illustrated with plans, diagrams, and reproductions of photographs, and forms a valuable contribution to the literature upon the subject.

GODFREY SYKES.

Coast Erosion and Protection.— Ernest R. Matthews. Second edition, enlarged. London : Charles Griffin & Co. 1918. *12s. 6d. net.*

Two interesting chapters have been added to the latest edition of this standard work, which have added greatly to its value. In the first of these the author deals with the effects of natural or artificial projections upon coasts, as influencing their configuration, and describes experiments devised and carried out by himself in order to determine the underlying causes for such changes as take place. In the second added chapter he has elaborated more fully the subject of the crushing and rending force of waves against breakwaters and piers, and offers suggestions for certain modifications in the design of such protective works.

So much of the work that has been done in this important branch of engineering is hidden away in the Proceedings of various Engineering Societies, where it is inaccessible to the non-technical reader, that an addition to the semi-popular literature upon the subject is always welcome.

G. S.

THE MONTHLY RECORD

EUROPE

The Rainfall of Essex.

A FURTHER paper on county rainfall is contributed by Dr. H. R. Mill in the Geological Survey Memoir 'The Water Supply of Essex from Underground Sources' (1916), on the same lines as in previous memoirs. The surface of Essex, though most pleasingly diversified, is much less boldly relieved than that of the neighbouring south-eastern county of Kent, and, in accordance with well-understood laws, the distribution of rainfall is more uniform and is, indeed, remarkably simple, ranging from just under 20 inches a year on the island of Foulness and the Southminster Marshes to over 25 inches in the north-west of the county, on the edge of the East Anglian Ridge, and to close upon 30 inches in the neighbourhood of Epping Forest, where the ground rises above 350 feet between the valleys of the Lea and Roding. The isohyetal map brings out clearly how the least elevation tells in increasing the mean annual precipitation, and the chain of low elevations parallel with the coast and rising to a height of at least 100 feet (one of them, crowned by Langdon or Laindon Hills village, being a picturesque eminence nearly 400 feet above the sea) is marked by just so many rings of the 22·5-inch isohyetal. The mean general rainfall of the county for the thirty-five year period 1876–1910 is calculated as 23·5 inches. In the east the wettest month was October 1880, when 8·21 inches were recorded at Shoeburyness, an extraordinary monthly total for this part of England, whilst in the west the wettest was September 1896, with 7·72 inches at Epping. The driest month was February 1891, when no rain at all was measured at Chelmsford and Epping. The wettest year in the record was 1903, with an excess of 46 per cent., and the driest 1885, with a deficiency of 25 per cent. The mean monthly rainfall is lowest in April, with 6·5 per cent. of the annual fall, but January, February, and March are almost as dry. The percentage rises to 9·7 in August, drops to 8·1 in September, and rises again to 11 in October, which, as in most parts of England, is the wettest month of the year. The double maximum in August and October is a seasonal characteristic common to the eastern counties, but whereas in Lincolnshire the two are nearly equal, in Kent and Sussex the August maximum is relatively still lower than in Essex. One may quote the following paragraph, which is interesting: "The rising in the level of all the isohyets towards the north-east shows, as in the case of Hampshire and Sussex, the power of the south-westerly winds as rain-carriers, a greater elevation being necessary to reduce the temperature of the residual water-vapour to the saturation point as the absolute humidity is reduced by the formation of rain."

Recent Fluctuations of the Lys Glacier, Monte Rosa.

Careful observations of the movements of advance or retreat of this glacier have been made during the period 1901–1917, first by Prof. Dainelli (to 1910) and latterly by Dr. Umberto Monterin, who summarizes the results in the *Rivista Geografica Italiana* for 1918, June–August. Before 1901 records show that about 1859 the glacier-front was in a position of decided advance, but that a retreat succeeded lasting till about 1884, when a slight advance once more took place. In 1901, when the recent observations were inaugurated, there were unmistakable signs of recent retreat, which probably began about 1890. This retreat continued, with a slight break in 1903–1904, till 1913, since which a fairly rapid advance has supervened, well indicated to the eye by the diminution

of the morainic material at the glacier-front. The best series of observations were made in the summers of 1914–15, but were insufficient to test the correctness of the idea that glacier-tongues move more rapidly in summer than in winter. The writer gives details and sketches of the changes in the front of the glacier during the period of observation. He mentions that, besides the usual relatively greater movement in the centre than at the sides of the glacier, his measurements also prove a movement considerably more rapid on the right than on the left side, due to the form of the valley. There seems to have been a general and simultaneous advance of all the Italian glaciers of Monte Rosa, at least during 1914–15.

Recent Earthquakes in Italy.

The new volume of the *Bollettino* of the Italian Seismological Society (vol. **21**, 1918) contains three important papers on recent earthquakes in Italy. In the longest paper of the three (pp. 47–101), Dr. G. Agamennone describes an interesting series of earthquakes which occurred in February 1906 in the Alban Hills, an old volcanic district 14 or 15 miles south-east of Rome. After several years of comparative quiet, the new series began on February 20 and lasted for exactly three days. In this time twenty earthquakes were recorded, half of which were imperceptible to man. The only important shock was that of February 21 at 8.49 p.m. (G.M.T.), which was just strong enough to crack the walls of some poorly built houses. From the map of this earthquake, and from the places at which the other shocks were observed, it is probable that the whole series originated in a focus either within or very close to the Lago di Albano, and at no great depth below it. But, though this lake occupies the crater of an extinct volcano, Dr. Agamennone considers that the earthquakes were not of volcanic origin, but were due, as in other countries, to the readjustment of the strata.

Since the earthquake which ruined Avezzano on 13 January 1915, probably the strongest Italian earthquake is that which occurred on 26 April 1917 in the upper Tevere Valley. According to Prof. E. Oddone, who has studied this earthquake (pp. 9–27), the area in which the shock was felt most strongly lies on the right bank of the river between the tributaries Minima and Sovara, the centre of the area being in lat. 43° 28′·2 N., long. 12° 7′·7 E. Though the principal part of the shock consisted of only four or five vibrations, lasting but a few seconds, these were sufficient to cause serious damage to buildings within an area of about 75 square miles, and to produce destruction in a small district round Monterchi as complete as that of Messina in 1908 and Avezzano in 1915.

The province of Ancona is one of the well-known seismic districts of Italy, and the occurrence of numerous shocks and rumblings in October and November 1917 led the Government to appoint a committee for their investigation. Their report (pp. 37–46) is written by Prof. Oddone. There were two main shocks, one on October 21, the other on November 5, the latter of which was just strong enough to cause some slight damage to buildings. Shocks continued to be felt until the end of November, and, after the 5th inst., were in places so frequent that the ground seemed to be in a continual state of trembling. The shocks were all marked by their brief duration, the rapid period of their vibrations, and the rumbling sound which accompanied them. There were apparently two foci in action, one, on October 21, very near Ancona, the other, on November 5, a few miles to the south-east of that town.

AFRICA

An Ancient Harbour at Alexandria.

An interesting account, by M. Gaston Jondet, of the remains of building works along the coast of what was once the Island of Pharos, but is now united to the mainland by the strip on which the city of Alexandria has been built, has been published in the *Mémoires* of the Institut Égyptien (t. ix., 1916). The most detailed and complete investigation is devoted to what the author regards as an ancient harbour or dock some 2360 metres long and about 300 metres broad, surrounded by massive quays and breakwaters extending to more than 4 km. in length. Later researches, less complete, led him to extend the harbour works both in a seaward direction and north-eastwards along the coast, till they now cover about 4½ km. in length and about ¾ km. in width. Nearly all these old buildings are regarded as the walls and breakwaters of an old port, and all are now submerged to varying depths below sea-level. The masonry is described as of a singularly massive character, individual stones having dimensions of 2 to 5 and even 7 or 8 metres, and the works are regarded as being of Egyptian origin, probably constructed by the same dynasty as built the great pyramids; the complete absence of any reference to them by classical authors being attributed to their having fallen into ruins and become submerged before the arrival of Alexander the Great. The cause of the submergence is discussed and attributed to settlement due to seaward creep of the softer clays of the underlying rocks, and not to any general change in the relative level of land and sea. This conclusion is based partly on the varying depth of submergence—which is generally from 2 to 3 metres, but falls to half a metre in the parts nearest to the present dry land, and rises to nearly 9 metres in the most seaward remains discovered—partly on the author's interpretation of the buildings as old quay walls, which must originally have all been of the same height above sea-level. It is with regard to the latter point that doubt arises. When we read the description of harbour after harbour, of the military port, the commercial port, the fisherman's port, and so on, even to the harbour-master's private harbour, it is difficult to resist a feeling akin to that expressed by the proverb, "there is nothing like leather," or a doubt as to whether M. Jondet has not allowed the fact that he is a harbour builder himself to bias, unconsciously, his interpretation of the evidence. This, however, is a matter for future investigators to explore, and does not affect the importance of his discoveries or the interest of his account.

AMERICA

American Dustfall.

The circumstances attending a fall of snow containing colouring matter at Madison, Wisconsin, on 9 March 1918 are discussed by A. N. Winchell and E. R. Miller in the *American Journal of Science* for October 1918. It is stated that the coloured snow came down at Madison in the form of "moist snow mixed with sleet," during the passage of an unusually intense and fast-moving cyclonic disturbance. The "dirty snow" was found on inquiry to have been observed also at various other places in this part of the States, and it is estimated that the total quantity of dust amounted to at least a million tons. The microscopic examination of the deposit indicated that its origin must have been in a very arid region, and not in any part of the Mississippi valley. The trajectories of the air reaching the Madison district on the date in question were cartographically traced and found to support the supposition that the

dust came from an arid region in the south-western part of the country where silicious feldspathic rocks abound. Such rocks are common in New Mexico and Arizona, and it is conjectured that the material was whirled up from the surface on the afternoon of March 8. The evidence, say the authors, here presented that a single storm may transport a million tons of rock material a thousand miles or more, emphasizes the importance of the wind as a geological agent. It will be recalled that an important dustfall occurred in the south of England early in 1903, and was traced by Dr. H. R. Mill and Mr. R. G. K. Lempfert to the sands of the Sahara.

It may, perhaps, be advisable to point out that the expression "moist snow mixed with sleet" quoted above is no loose phraseology, and that throughout the paper the term "sleet" is employed in the specific American meteorological sense to denote frozen rain-drops, such as cause the ice-storms which are so common in the New England States. Ice-rain does occasionally fall in England, producing the phenomenon known as "glazed frost," and it is a pity that a special term is not reserved by British meteorologists likewise for this third specific form of frozen precipitation which is genetically and structurally different from the other forms snow and hail, the former being apparently frozen vapour and the latter a composite structure of frozen rain and snow. In England "sleet" is usually understood to mean a mixture of rain and snow, but in many of the great English authors it is used to signify any form of inclement winter precipitation whether liquid or frozen.

The South American Interior in the Sixteenth Century.

Our note on this subject in the *Journal* for November 1918 (p. 332) has brought in reply a communication from Baron Erland Nordenskiöld, the well-known authority on South American ethnology, which satisfactorily solves the question of the source of some at least of the place-names mentioned as recurring in many of the maps of the second half of the century in question. At the same time it draws attention to some interesting but little-known facts concerning the earliest penetration by Europeans into the heart of the continent on the borders of Bolivia and the Argentine. In the *Geographical Review* for 1917 (vol. 4, pp. 103 *et seq.*) Baron Nordenskiöld discussed a remarkable westward movement of the Guarani tribes of the region of the Upper Paraguay and Gran Chaco towards the borders of the Inca Empire early in the sixteenth century, a movement which he qualifies as an actual invasion. This invasion was closely associated with the doings of a Portuguese adventurer, Alejo Garcia, noted for his knowledge of the Guarani language, who, if the somewhat vague but generally concordant statements of the chroniclers are to be trusted, was actually the first European to cross the bounds of the Inca Empire. The story is told by Rui Diaz de Guzman that four Portuguese, of whom Garcia was one, set out from the coast of Southern Brazil in 1526 to explore the interior. Crossing the Paraná and Paraguay they continued their journey westward accompanied by two thousand Guarani Indians, and reaching the mountains plundered and killed the people dwelling there under the Inca rule. Returning to the Paraguay laden with booty, Garcia and his companions were murdered, with the exception of his son, then a boy. Other Portuguese who followed were also murdered, but a great number of Indians betook themselves to the parts where Garcia had been. Such an invasion by the Chiriguanos (the principal Guarani tribe concerned) was placed by Garcilaso de la Vega considerably earlier than Garcia's time, but Baron Nordenskiöld shows that all other authorities agree in placing it early in the sixteenth century. He finds in the accounts of the early Spanish doings on the headwaters of the Paraguay (under Cabeza de Vaca

and others) a good deal that confirms Guzman's story, and that of a date previous to his work. Now among the Indian names mentioned in this connection we find three of the enigmatical names on the Dutch maps of the second half of the century—Charcara(e)s, Chanes (Indian tribes, the latter still existing in that region), and Itapoan (a chief). It is remarkable that an echo of these obscure events should be traceable, however slightly, in the general maps of South America in the atlases of the period, which otherwise show little influence of the journeys of early adventurers in the heart of the continent. As was so often the case, when once admitted to the maps, the names were copied and recopied for a number of years. Baron Nordenskiöld thinks that Garcia probably went to South America with the *first* expedition of Christoval Jaques to the La Plata, apparently about 1521–22, of which but little is known. In a postscript he mentions that a similar conclusion as to the anticipation of Pizarro by Garcia had been reached in 1904 by a Paraguayan writer, Dr. M. Dominguez.

AUSTRALASIA AND PACIFIC ISLANDS

Geological History and Present Outline of New Zealand.

Mr. C. A. Cotton, who is known as a keen student of New Zealand physiography, contributes an interesting paper on "The Outline of New Zealand" to the *Geographical Review* for October 1918, in which he briefly traces the mode of origin of the existing land-mass of New Zealand, and describes and classifies the various types of coast-line in relation to the geological history. It is illustrated by a number of excellent sketches and photographs, bringing out clearly the typical forms of the coasts in the several parts. Mr. Cotton points out that it is a mistake to suppose that the present-day New Zealand represents at all closely the land that existed in this part of the world in early geologic epochs. A large land did exist here in Mesozoic times, but its outlines are quite unknown, and it seems inadvisable to think of it as an ancestral New Zealand. It was only at the end of the Cretaceous and Tertiary sedimentation that there arose, as a concourse of Earth-blocks, the initial forms of the present land-mass, modified by later uplift and depression, as well as by weather and waves. Some parts of the coast are the sequential forms developed from lines of fracture bounding a residual mass after marginal portions had foundered—an event which took place in relatively modern times; but the rapidity with which an original fault-coast is modified by movements of depression makes it difficult to decide whether all or only some of the outlines resulted from marginal foundering. The striking physical differences between the two main islands—in strong contrast with the close political association between them—lead to an inquiry as to the origin of the dividing strait; and of the various explanations which have been put forward Mr. Cotton favours that which attributes it to differential movement of earth-blocks—possibly rather a failure of the blocks here to rise with those which now constitute the adjacent parts of the two islands than an actual subsidence. Yet there is biological evidence that the dry land areas on either side of the strait were at one time connected. Central New Zealand is a seismic region, and the record of shocks originating beneath the north-western entrance to Cook Strait may indicate that subsidence along faults is still in progress. Although almost every conceivable type of coast is represented somewhere in New Zealand's long coast-line, the principal types are classed by Mr. Cotton as follows: (1) drowned coasts, the original form undecipherable, but from analogy probably of the fault-coast type; (2) drowned volcanic coasts; (3)

fault-coasts, nearly all subsequently uplifted and therefore of the multicycle type; (4) prograded coasts (the reverse of retrograded). The coasts are described by Mr. Cotton in order, with explanation of the steps by which the present form was arrived at.

GENERAL

Mountain Ranges and Ethnic-Linguistic Boundaries.

It has long been recognized that the crest-line in mountain ranges is as a rule far from coinciding with the lines separating the different races or linguistic groups inhabiting the neighbouring regions, however generally such crest-lines may have been adopted as political boundaries. It has often been pointed out that the people inhabiting the side of the range with the more gradual and easy slope towards the lowland tends to pass the crest-line and occupy also the side of the range with the steeper fall; and examples have been given from the Himalayas (where the Tibetans have crossed the main crest towards the south), the Alps (where the Slavs and Germans have similarly pushed southward), and other ranges. The causes of this are somewhat complex, but there is no doubt that purely geographical factors have had an important influence side by side with those of a political or economic nature. The working of the principle in the case of the Eastern Pyrenees is discussed with some care in the *Rivista Geografica Italiana* (1918, fasc. vi.–viii.) by Signor F. Musoni, who at the end of his paper deals more briefly with the Western Alps from the same point of view. The Catalan ethno-linguistic group, with more decided affinities with the south than with the north of the range, has spread northwards across its eastern extremity and occupied the greater part of the modern French department of Pyrénées Orientales. Opinions have differed as to the antiquity of this northward movement, but whether, as some have thought, it was brought about by the political events of the middle ages, during which Roussillon was long united with Aragon, or whether the present distribution dates from a much more ancient period, even before the Roman Conquest, in either case the facts harmonize with the influence that would naturally be exerted by the physical configuration of this part of the range, where the means of communication are far easier from south to north than in the reverse direction. Although the diffusion of the Catalan language on either side of the range does not necessarily prove a racial identity, the latter is strongly indicated by the results of recent anthropological research, which have shown that dolichocephalism prevails throughout the Catalan domain. This supports the view that the boundaries of that domain took form in pre-Roman times. Somewhat further west, where the range forms a more formidable barrier, the Catalan boundary coincides with the crest-line and political frontier, and still further west the original position is reversed, the headwaters of the Garonne affording an easy means of transit for the Gascon elements to the south of the political frontier. In the western Alps somewhat similar conditions are traceable in the spread of French influences into the upper Piedmontese valleys. For a discussion of the general principle on somewhat similar lines the reader may be referred to a paper by M. Regnault read before the Paris Society of Anthropology in 1892 and noticed in the first volume of the *Geographical Journal* (p. 175).

The Geographical Tripos.

The establishment of an Honours Degree in Geography in the University of Cambridge marks an important epoch in the history of geographical educa-

tion. We have at last the prospect of escaping from the vicious circle of argument which denied Geography its proper place in the higher examinations because it was not a subject for University honours, and made it difficult to obtain its proper place in the University teaching because it was not a subject in the higher examinations for public appointments. The Geographical Tripos will greatly stimulate the teaching of Geography in the University, and will call for the better endowment of the school and improvement in position of the teaching staff. The institution of a full Professorship must be the next step in the development, and we believe that the University Association has it in the forefront of its programme. We hope to publish in a following number some account of the scope of the new Tripos, and the place it may take in Cambridge education.

Errata in November 'Journal.'

In Mr. MacCarthy's paper on German Plans for Railway Development in German East Africa:

Page 316, line 15, *for* 8550 *read* 1550 metres.
" 314, line 7 from bottom, *for* 370 *read* 280 miles.
" 314, second line of article, *for* agriculture *read* apiculture.
" 321, line 2 from bottom, *for* Zemagrut *read* Lemagrut.

OBITUARY

Sr. D. Enrique d'Almonte y Muriel.

AMONG distinguished geographers whose loss during the past fateful year has to be regretted the name of Enrique d'Almonte, though perhaps not widely known to Englishmen at home, deserves prominent and sympathetic mention. Some eighteen years of his life were spent in the service of Spain in the Far East, where his duties in connection with the geological survey of the Philippine Islands afforded him free scope for the exercise of his talent as a cartographer. The American occupation of the Philippine colony brought D'Almonte's map-work under the notice of Dr. Warren D. Smith, Director of the American Bureau of Mineralogy, who declared that he "must regard him as one of the great explorers of the twentieth century," and, already ten years ago, wrote in the *Journal* of our Society (vol. **34**, p. 534), "I do not know if he has ever received fitting testimony of appreciation from his fellow-geographers of the world. If not, this tardy recognition should soon be forthcoming"—a prediction which has been verified by well-judged praise of the man and his achievements expressed last year by the President and other distinguished Fellows of the *Real Sociedad Geográfica* at Madrid, of whose Council D'Almonte was himself a member.

In England we know D'Almonte chiefly by his maps and descriptions of the Spanish possessions in Western Africa. His versatility of character and untiring energy were backed by a strong bodily constitution and a capacity for resisting the many pests and toxæmias by which an explorer's life in hot countries is commonly beset. This immunity proved of signal value to him when investigating the topography, population, and economic resources of the river valleys and forest tracts of the Muni Territory, the fascinating but unhealthy island of Fernando Póo, and the widely different conditions of climate

and environment in the Spanish area of the Sáharan Desert. His maps of Muni on a scale of 1/200,000 and the Spanish Sahara 1/M were published in 1903 and 1914, supplemented by descriptive accounts, under the modest title of *Someras Notas*—rough notes, and *Breve descripcio*—short account, in the *Boletín* of the *Real Sociedad Geográfica* (vols. 44 and 56). They are highly instructive, and add important chapters to general knowledge regarding Spanish possessions and protectorates in Western Africa.

In later years Sr. d'Almonte devoted himself to an inquiry into the evolution of racial distinctions in Indonesia and Malaya, the first results of which display their author as an indefatigable ethnographer and philologist (*Boletín R.S.G.*, vol. 59 (1917), pp. 7–321, 398–478). While returning to the Far East in order to resume and extend those studies, his life was abruptly and prematurely brought to a close by the operation of a German mine in the vicinity of the Cape of Good Hope—a misfortune which has elicited genuine sympathy and regret in his native country, and must appeal to all geographers, irrespective of nationality.

B. G. C.

CORRESPONDENCE

The Names of Himalayan Peaks.

I HAVE just read Dr. Kellas's note on the Nomenclature of Himalayan Peaks in the October number of the *Journal*. I fully admit the objections to the use of personal names, but I would make an exception in the single case of Everest. The name itself is such an uncommon one that the fact of its being a personal one is not forced on our notice as would be the case with that of any other of the pioneers in Indian geography. I doubt if the name Mount Hodgson or Mount Lambton, for instance, would ever have become established throughout the English-speaking world as has Mount Everest.

In cases where Tibetan or other local names can be found, the correct etymology should certainly, as suggested by Dr. Kellas, be determined by linguistic experts. The necessity for this is apparent from the two cases discussed by him. The correct spelling of the Tibetan word for "Lady" is Jomo, not Chomo; the name Jomolangmo means "The Lady of the Elephant." Another Tibetan name which Sarat-Chandra Das gives for Mount Everest is Jomogangkar, "The Lady of the White Snows," or "The Jungfrau of the Himalaya." The word Jomo appears also in the name Jomothari, "The Lady of the Holy Mountain," corrupted in maps into Chumalari.

The Tibetan for ice, or perpetual snow, is Gang; Gangri, not Kangri, is the correct spelling of the word, which means "Snowy Mountain." Jäschke gives Gangchenjenga, "The Five Kings of the Great Snows," or Gangchendzonga, "The Five Receptacles of the Great Glaciers," as the name of the mountain commonly spelled Kinchenjunga. The latter form is, I think, too well established to make a change desirable.

R. A. WAUHOPE.

Dehra Dun, 4 January 1919.

Lake Formation and Desiccation in Africa.

Referring to the note in the *Journal* of August 1918 on Lake Fagibini near Timbuktu: in the Sokoto province of Nigeria I found lake formation

associated with desiccation in the following manner. Tributaries of the Sokoto River which have ceased to flow have had their mouths closed by detritus brought down by the flood of the river, which, in raising its own bed, has barred their valleys. The resulting lake was fed each year by the flood water from the river, and the sediment dropped when the water lost its velocity in the backwater round the bar.

At Gaudi, where Lake Kubiri provides a very clear example, the bar is 16 feet above what must have been the original valley-bottom. The lake was perfectly dry owing to failure of the Sokoto River for many years to reach the level of the bar it had constructed when its water-supply was more abundant. I cut a canal about 1200 yards long from a point up-stream, and the lake is now 11 miles long and contains some 12,000,000 cubic yards of water. Half a dozen dry depressions due to the same natural causes were dealt with in the same way, with the result that lakes containing over 20,000,000 cubic yards and covering nearly 3000 acres now stand there. Many other examples remain which will be dealt with in due course, and the benefit to the people in this semi-arid region is out of all proportion to the absurdly small cost of the work required.

From observations it appears that during the eight months of the dry season about 4 feet of water is taken from lakes by evaporation and soakage, both processes of value to vegetation in the vicinity. Thus from every acre of water over 4 feet deep some 6050 cubic yards of water are used up annually. If the lake is able to refill itself at high river this forms the annual profit, the water saved from the sea each year for local use. Of course the direct benefits to the people for fishing and irrigation are immense, but this factor of evaporation is a very real asset.

The conditions in the Timbuktu area are on a much bigger scale, and the benefits to be derived from their improvement correspondingly great. Fagibini and its adjoining lakes appear to have an area of about 500 square miles. The annual evaporation from this would be about 2,000,000,000 cubic yards—well worth saving from the sea. A short study of the large-scale French map of Timbuktu suggests that the large collection of lakes in the vicinity may be due to similar causes, the floodwater of the Niger having brought down masses of detritus from the hills where it rises and spread it over the plain, raising the river-bed, blocking valleys, and creating depressions.

It would seem of the utmost importance that the storage of the Niger flood-water in these lakes should be facilitated in every way.

H. S. W. EDWARDES, D.O.

Sokoto, Nigeria, 12 December 1918.

Spitsbergen.

I am desired to draw your attention to pp. 95 and 96 of your Society's *Journal* for the current month.

The first paragraph of Sir Aubrey Strahan's note quotes R. Högbom as writing in 1913 that "he regarded a line drawn 10 kilometres from the coast as the probable limit of possible mining." From that opinion my colleagues and I absolutely and entirely dissent. As to his second statement (occurring on p. 96) that "the iron deposits reported by English explorers contain only about ten to twenty per cent. of iron," the analyses of the iron ores brought home by the officials of this Company in the autumn 1918 gave on assay the following results :

1. Messrs. Allen & Partners, Sheffield ... 68·2 per cent. of iron
2. Messrs. Pattinson & Stead, Middlesboro' 66·9 „ „
3. Messrs. Amalgams Co., Sheffield ... ... 65·8 „ „
4. Prof. Turner, Birmingham ... ... 59·04 „ „

thereby fully confirming the previous analyses reported by our engineers made in 1913 and 1914.

Yours faithfully,
FRED L. DAVIS,
Chairman Northern Exploration Company.

13 February 1919.

MEETINGS: ROYAL GEOGRAPHICAL SOCIETY: SESSION 1918–1919

Third Afternoon Meeting, 20 January 1919.—Sir Aubrey Strahan in the Chair.

PAPER: British Survey on the Western Front. Lieut.-Colonel H. S. L. Winterbotham, C.M.G., D.S.O.

Fifth Evening Meeting, 27 January 1919.—The President in the Chair.

ELECTIONS.—Lieut.-Colonel George A. Beazeley, D.S.O., R.E.; Lieut.-Colonel The Hon. Henry George Orlando Bridgeman, D.S.O., M.C., R.A.; Frederick Brown; Lieut.-Colonel Sir Walter James Buchanan, K.C.I.E.; Enrique Budge; Rev. William Burton; Rev. Louis A. Ewart; Captain Basil H. Fanshawe, R.N.; Commr. Sir Lionel Fletcher, R.N.R.; Captain Thomas Harkness Galbraith, R.E.; Marchese N. Venturi Ginori; Francis R. Jones; Philip R. Kemp; James Kennedy; Alfred G. Le Clercq; Lady Markham; Donald Mellor; Captain C. W. F. Morgan, R.A.F.; Rev. William Mortlock; Frederic Charles Tandy Mortimer, F.PH.SOC.; Miss Charlotte Alice Olding; H. H. Phillips; Major W. A. Phillips; Lieut.-Colonel E. J. L. Pike; Charles Bothwell Pratt; Miss Annie Hopkinson Ramsbottom; J. W. Ryan; Frederick G. Sale; Lieut.-Colonel Martin Archer-Shee, M.P.; Lieut. Harold G. Smedley; Miss Caroline Mary Sullivan; Mrs. Marion O. Tomlin; Kenneth S. Topping; Captain H. W. Acland Troyte; Major Charles Claude Wallace.

PAPER: Eastern Tibet. Mr. Oliver Coales.

Sixth Evening Meeting, 10 February 1919.—The President in the Chair.

ELECTIONS.—Michael Corbet Andrews, F.R.S.G.S.; Captain Horatio Barber, R.A.F.; Francis Charles Brading; William Letchworth Bryant; Charles Edward Fletcher; Mrs. J. Grimble Groves; Mrs. Heath; Lieut. Brian C. H. Kimmins, R.H.A.; Lieut.-Colonel Bertram Francis E. Keeling; Major Thomas Spencer Laycock; Lieut.-Colonel F. L. C. Livingstone-Learmonth, C.M.G., R.F.A.; Dougal O. Malcolm; Major R. T. McEnery, I.A.; Charles Kingsley Meek; Captain Richard Brian Murray, R.E.; Major William Newbold, O.B.E., R.G.A.; Lieut. John Williams Damer-Powell, R.N.R.; F. Hamlyn Price; Major Charles Hugh Stockley, M.C., I.A.; Captain Arthur J. Swinton; John M. Vaughan.

PAPER: The Adriatic. Commander Roncagli.

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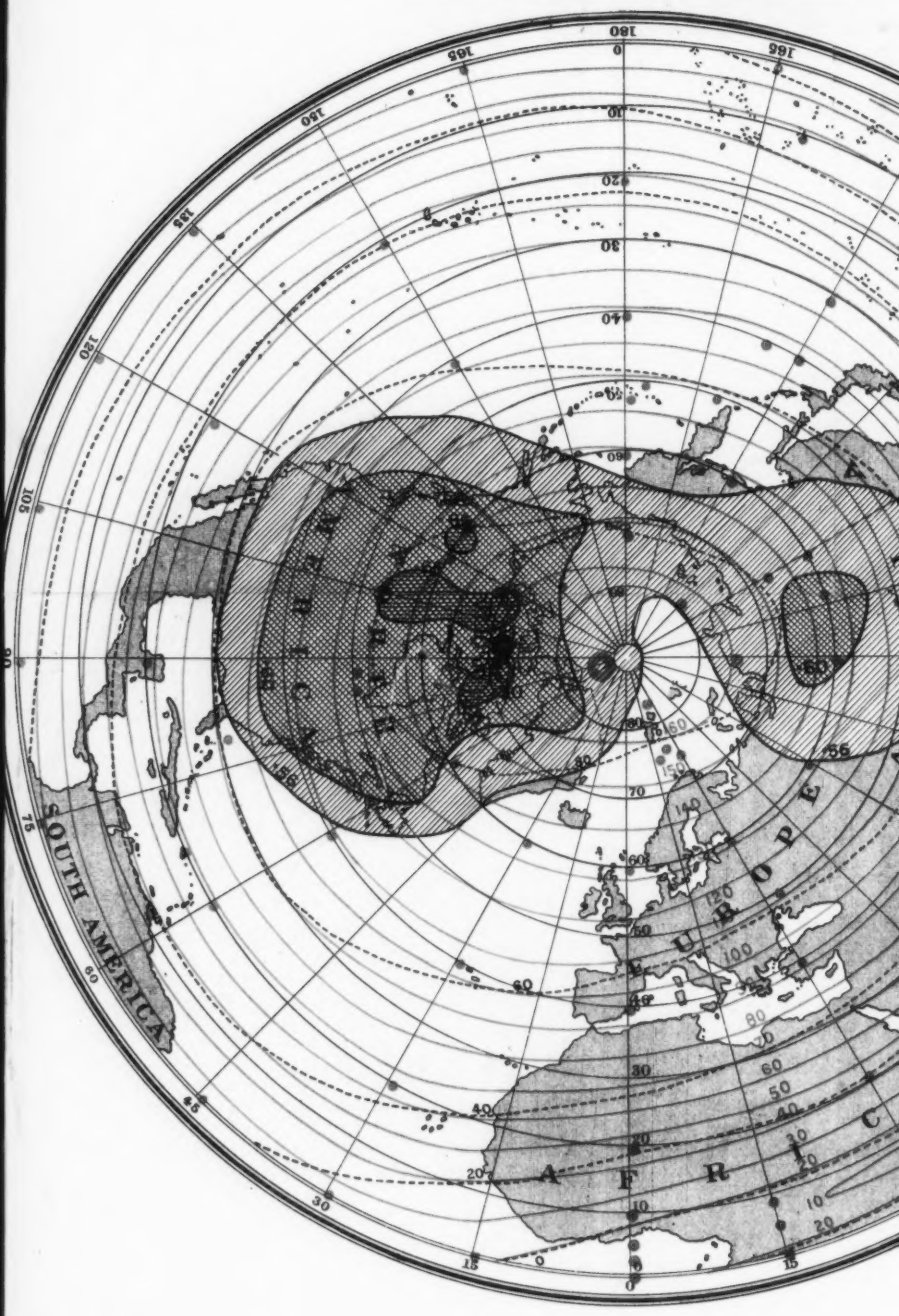

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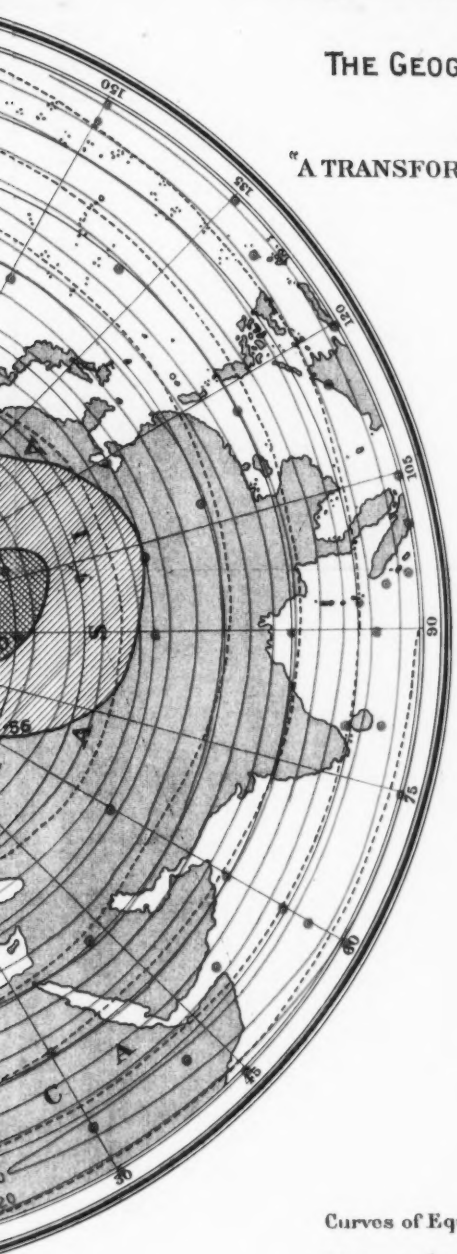

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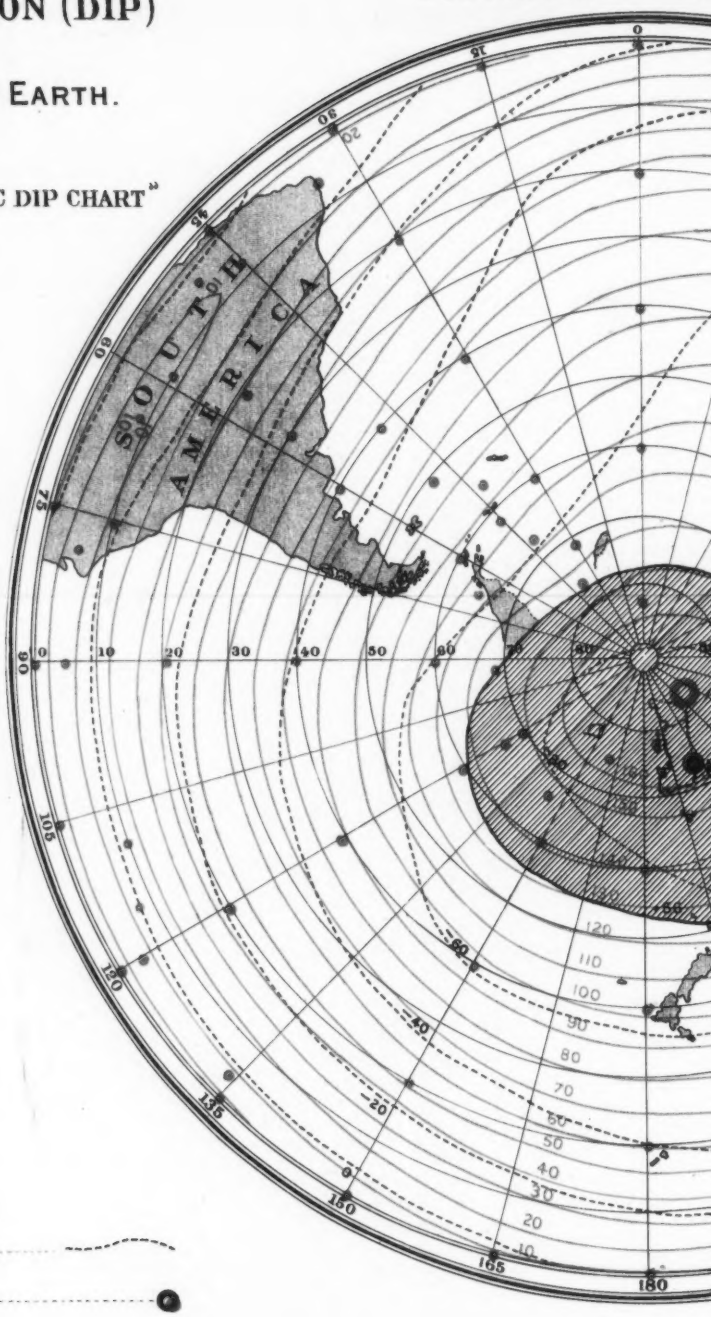

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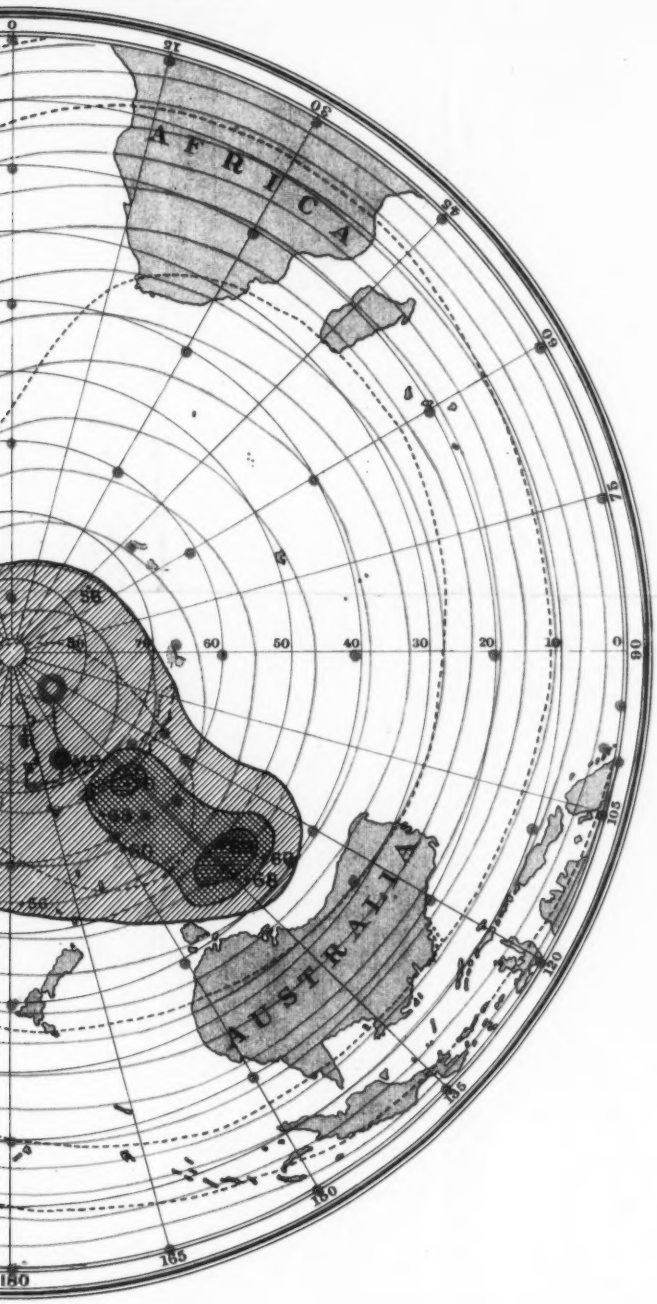

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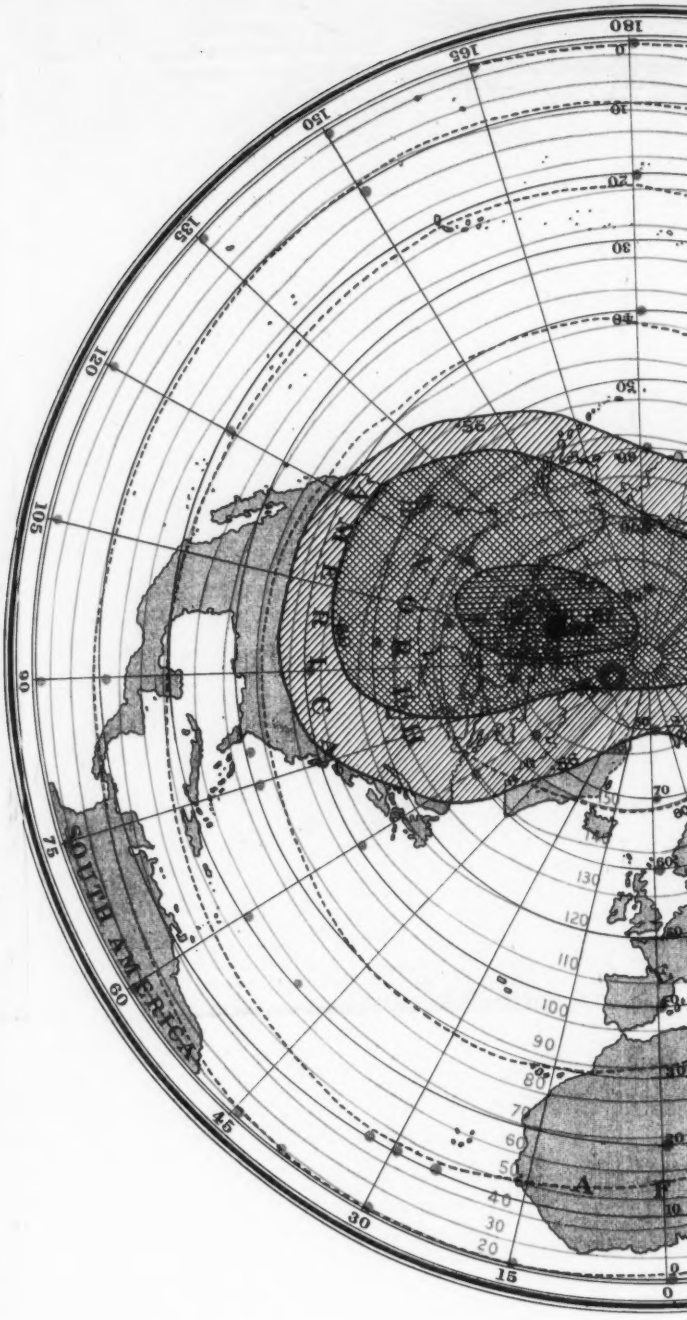

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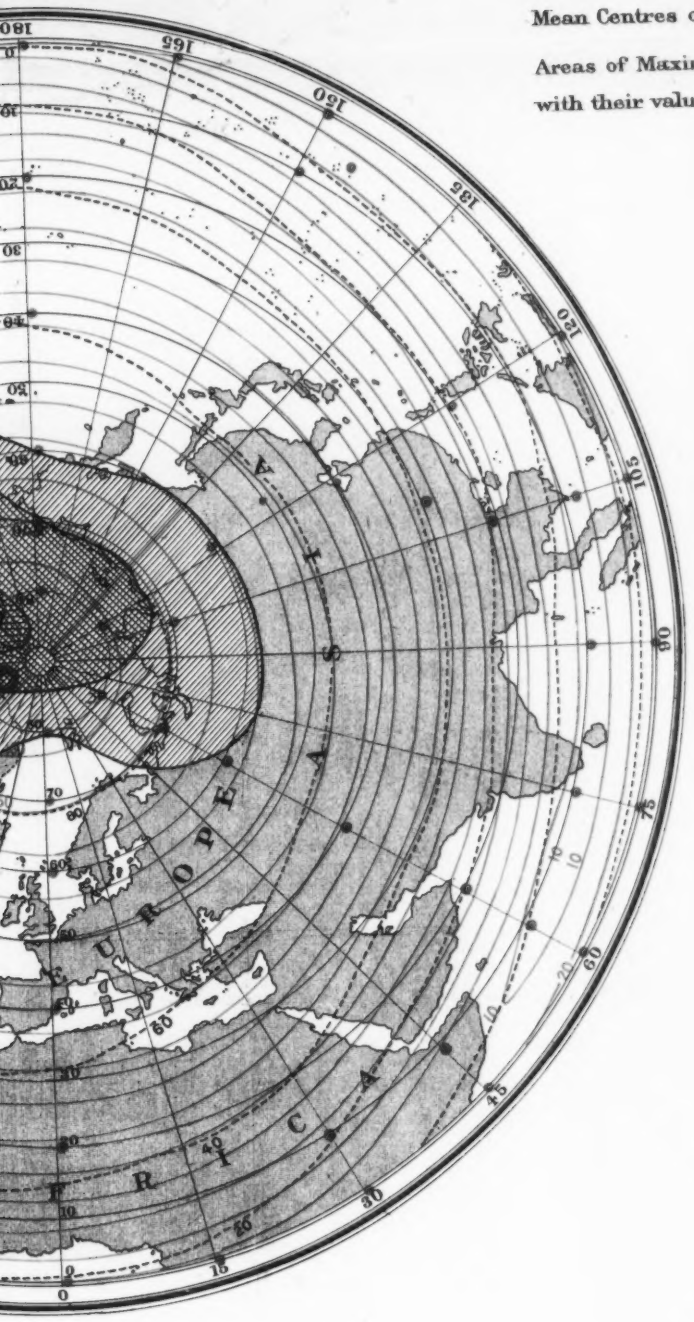

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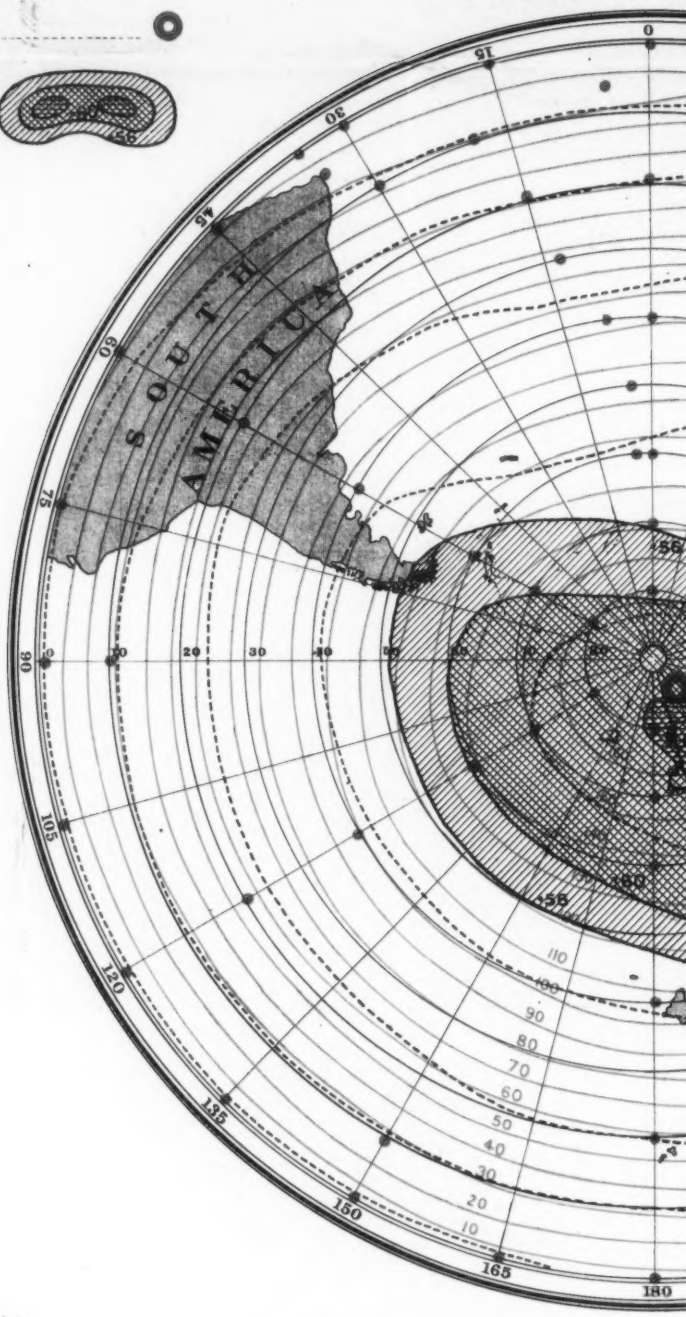

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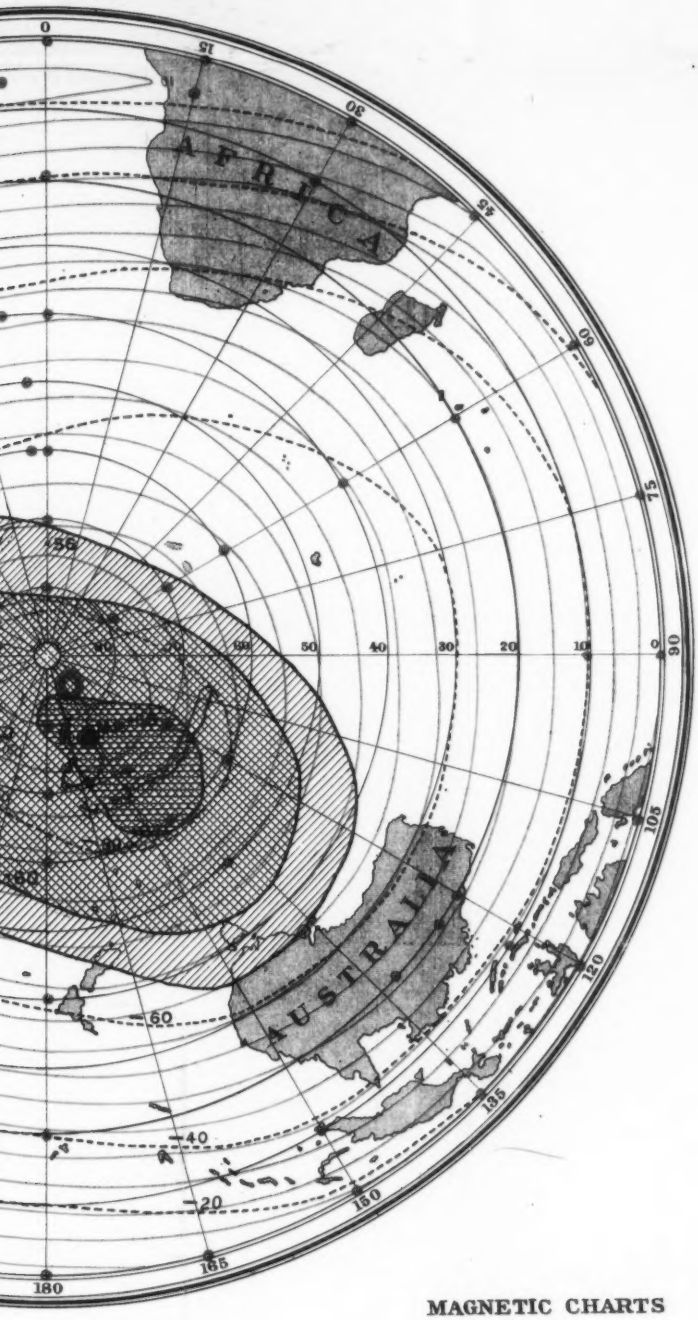

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